ICAR

SUMMER INSTITUTE
ON
FISH PROCESSING TECHNOLOGY

1st to 31st May, 1978

CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY
COCHIN - 682 029

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

FOREWORD

Among the 22 Summer Institutes sponsored by the Indian Council of Agricultural Research on Agricultural and Animal Sciences during 1978 one was on the topic 'Fish Processing Technology' organised at the Central Institute of Fisheries Technology, Cochin from 1st to 31st May, 1978. The Summer Institute was conducted with the aim of acquainting the participants, who included a wide cross section of technical personnel working in different capacities on the development of fisheries including education drawn from all over India with the latest developments in the field of fish processing technology. The 'Institute' consisted of lectures by experts in their respective fields, practicals, field trips etc. An account of the proceedings of the Summer Institute is presented in the following pages.

(G.K.Kuriyan)
DIRECTOR

Central Institute of
Fisheries Technology,
Cochin, 31st May, 1978.

SUMMER INSTITUTE
ON
FISH PROCESSING TECHNOLOGY

List of Participants

Regn.No.	Name and Designation	Sponsoring Authority
✓ 1.	Sri.K.G.S. Nair, Instructor, Office of the Assistant Director (Training) Department of Fisheries, K.S.Bhullar Road, Veraval.	Commissioner of Fisheries, Department of Fisheries, Govt. of Gujarat, Bl.No.0-2, New Mental Hospital Bldg., Asarwa, Ahmedabad-380016.
✓ 2.	Sri.A.P.Madhava Rao, Processing Supervisor, Andhra Pradesh Fisheries Corporation Ltd., 8-1-6A, Waltair Uplands, Visakhapatnam.	Andhra Pradesh Fisheries Corporation Ltd., 8-1-6A, Waltair, Uplands, Visakhapatnam, 530003.
✓ 3.	Sri.N.S.Sudhakara, Instructor, Fisheries College, University of Agrl., Sciences, Mangalore-1.	Fisheries ~~x~~College, Universit of Agrl., Sciences, Mangalore-1.
4.	Sri.N.K.Pavithran, Assistant Director of Fisheries (Trg.), Ernakulam.	The Director of Fisheries, Kerala, Trivandrum-10.
5.	Smt.S. Leelavathy, Asst. Director of Fisheries(Technology), Dept. of Fisheries, Calicut-5.	-do-
✓ 6.	Sri.George Joseph, Scientist S, Calicut Research Centre of CIFT, Beach Road, West Hill, Calicut-5.	The Director, CIFT, Cochin-682029.
4 7.	Shri. Sivagurunathan, Technologist, State Fisheries Technological Station, Cape Comorin, Kanyakumari Dist.	The Director of Fisheries, Teynampet, Madras-600006.

5	8.	Sri. Shrikrishna, Junior Demonstrator, C.I.F.E., Bombay.	The Director, Central Insttitute of Fisheries Education, P.B.No.7392,Kakori Camp, BOMBAY-58.
6	9.	Sri. Suresh Mishra, Lecturer in Bio-chemistry, B.R.D.Post Graduate College,DEORIA(UP).	The Principal, B.R.D. Post-graduate College, Deoria (UP)
7	10.	Sri.P.Jayachandran, Asst. Professor of Fisheries,Fisheries College,TUTICORIN.	The Registrar, Tamilnadu Agricultural Universitty, Coimbatore-641003.
	11.	Sri.Krishna Vinayak Lokara, Research Fellow, MPEDA,Cochin-16.	The Director, Marine Products Export Development Authority, P.B.No.1708,Cochin-682016.
	12.	Sri.Krishna Murthy, Research Fellow, MPEDA,Cochin-16.	-do-
8	13.	Sri.C.R.Trivedi, Sr. Research Assistant, C/o Asst.Director of Fisheries,ICAR, Port Okha.	The Commissioner of Fisheries, Dept. of Fisheries, Govt.of Gujarat, Bl.No.O-2, New Mental Hospittal Bldg.,Asarwa, Ahmedabad-380016.
9	14.	Sri.S.N.Mahajan, Asst. Research Officer, Marine Biological Research Station, Ratnagiri.	Konkan Krishi Vidya Peeth, Marine Biological Research Station, Ratnagiri-415612.
	15.	Sri.Sib Sankar Gupta, Scientist S1, Kakinada Research Centre, of CIFT,Kakinada-3.	The Director, CIFT,Cochin-682029.
10	16.	Sri.V.Singarayan, Research Assistant, (Fisheries By-products) Govt. Fisheries Station, Nagapatnam P.O., Thanjavur Dist.	The Director of Fisheries, Teynampet, Madras-600006.
	17.		

	17.	Miss. Meera Menon, (Demonstrator in Foods and Nutrition), Sri Avinashilingam Home Science College for Women, Coimbatore-641011.	The Principal, Sri Avinashilingam Home Science College for Women, Coimbatore-64011.
	18.	Sri.K.P.Antony, Lab. Technician,IFP, Cochin-16.	The Director, Integrated Fisheries Project,Cochin-682016.
11	19.	Sri.R.Ramachandran, Senior Instructor, Central Fisheries Extension Training Centre, 17-1-390, "Samad Bagh", Saidabad Colony,Hyderabad-500659.	The Director, Central Institute of Fisheries Education, Kakori Camp, Bombay-58.
12	20.	Sri.Chunduri Ramachandra Prasad,(Processing Supervisor) A.P.Fisheries Corporation Ltd.,Visakhapatnam-530003.	The Managing Director, Andhra Pradesh Fisheries Corporation Ltd., 8-1-6A, Waltair Uplands, Visakhapatnam-530003.

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List of Lectures		Name of lecturer
I. Resources		
Fishery resources of India	by	Dr. M.S. Prabhu
II. Fishing Methods	by	Sri.P.Appukutta Panicker
III. Biochemical & Microbiological aspects of Fish		
1. Fundamentals of Biochemistry and their relevance in fish processing.	by	Sri.P.D.Antony
2. Fundamentals of microbiology and their relevance in fish processing.	by	Sri. K.M. Iyer
3. Pathogens and faecal indicator organisms in seafoods.	by	Sri.T.S.G.Iyer
IV. Fish Processing		
1. Freezing of fish & shell fish	by	Sri.P.A. Perigreen
2. Canning of fish & shell fish	by	Sri.K.K.Balachandran
3. Dehydration of fish	by	Sri.P.K.Chakraborty
4. Curing of fish ..	by	Sri.T.S.Unnikrishnan Nair
5. Fish Curing - Impact of technology on Rural Development	by	Sri. A.P. Valsan
6. By-products from fish and fish wastes.	by	Sri.P. Madhavan
7. Diversified products from fish.	by	Dr.K.Gopakumar
V. Handling & Packaging		
1. Handling of fish on board the fishing vessel.	by	P.V. Prabhu
2. Handling, preservation & transport of fish.	by	Sri. M.R. Nair
VI. Quality control		
1. Quality control and inspection of fish and fish products.	by	Sri.Cyriac Mathen

VII. Processing Engineering

Engineering aspects involved in fish processing technology	by Sri.S.A.Pillai

VIII. General

1.	Statistical application in fish processing technology	by Sri.K.Krishna Rao
2.	Management techniques with special reference to fish processing factories.	by Sri.P.N.Mathew
3.	Present status of fish processing technology in India.	by Sri.T.K.Govindan

PRESENT STATUS OF FISH PROCESSING TECHNOLOGY IN INDIA

By

T.K. Govindan, Scientist S-2,
CIFT, Cochin-29

INTRODUCTION-HISTORICAL

Eventhough the technology of turning out traditional marine products like dry prawn pulp, salt cured fish, pickled (colombo-cured) fish, dried shark fins and fish maws, fish body oils etc. was wellknown to the Indians and the country had been an exporter of these commodities from time immemorial, fish processing technology in the sense in which it is understood today started to sprout in India barely two and a half decades back. These were perhaps the only seafoods exported from our country in the pre-independence period and the technology involved in their production was very simple and rather crude. Prawns were boiled in sea water right on the beach with or without addition of salt, sun-dried there itself on some mats wherever available, otherwise on the sand itself, deshelled by taking the dried product in gunny bags and thrashing on a hard surface and the broken shells separated from the pulp by winnowing. Salt curing was also carried out on the open beach itself and at later stages to some extent in huts in fish curing yards put up by the maritime states adjacent to the landing centres, where salt used to be supplied at subsidised rates so as to ensure application of salt in sufficient proportions to impart a reasonable shelf life to the finished product, the various steps involved viz; handling, dressing, cleaning, salting, drying, packing etc. leaving much to be desired from the hygienic and aesthetic points of view. Colombo-curing consisted of an initial salting after gutting and cleaning, followed by stacking under saturated brine with pieces of the dried pods of *Garcinia cambogea* (Gorukkapuli) fruits inserted in the stomach cavities. Shark fins used to be just sun-dried on the beach with or without an initial light salting, as also the fish maws or air bladders. Body oil, especially sardine oil, was pressed out of the pre-cooked fish, the main product being used for smearing on wooden country crafts as a preservative and the by-product viz., the press cake called 'guano' used either as manure or for poultry/cattle feed. Figures presented in Table 1 provide some idea as to the

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magnitude of exports of these commodities from India in the pre-independence period.

Table - 1

Export of marine products from India in the pre-independence period

Year	Quantity (Tonnes)	Value (Lakh Rupees)
1936-37	20,080	79.62
1937-38	17,200	69.05
1938-39	17,060	69.28
1939-40	18,170	69.71
1940-41	17,560	63.14
1941-42	18,690	60.19
1942-43	19,580	78.30
1943-44	22,130	155.50
1944-45	22,200	225.90
1945-46	28,880	266.30
1946-47	28,720	323.82

The escalation in the export values in the later years of the second world war as evidenced by the table may be attributable to the world wide inflation and greater demand for food materials, production of which received a set-back everywhere due to the war. The main markets for these commodities used to be our neighbouring countries viz., Sri Lanka, Burma, Malaysia, Singapore, Hongkong etc. a flourishing trade with even a barter deal struck with Burma on Indian dry prawn pulp for Burmese rice operating for sometime.

The Renaissance

Mechanisation of fishing and modern methods of handling and preservation of the catch were unknown in those days, with the simplest preservative viz., ice and quick transportation facilities not being available and the fish landing centres remaining unapproachable for

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vehicles in most of the places. Added to these primitive conditions, the post-war (World War II) recession dealt a crippling below to the already out-dated industry, our hitherto main markets imposing an almost blanket ban on imports of our fishery products, throwing thousands of our fishermen, processors and merchants into unemployment and a virtual state of starvation. The traditional products had no demand in the sophisticated and more well-to-do western markets and a lot of the harvested fish went waste as manure in our country. The industry continued to be under the influence of the evil stars until the year 1953, when the first ever consignment of a modest quantity of 13.26 tonnes of prawns frozen with foreign collaboration was exported to the United States. Though not totally an expected one, the cordial reception that this shipment met with at the destination sparked off a spontaneous chain reaction which marked the beginning of the era of renaissance and formed the corner-stone around which the whole of the present magnificent edifice of our fishing and fish processing industries has been built. Increasing demands for this commodity from foreign buyers caused installation of more and more freezing plants which in turn accelerated the fishing activities to meet the ever increasing demand for the raw material. As a good augury for the industry, the Indo-Norwegian Project (present Integrated Fisheries Project) was established around this time with the broad targets of introducing mechanisation of fishing, popularising improved handling and processing methods like icing and freezing, adoption of scientific marketing methods and improving the socio economic conditions of the fishermen community. Inspired by the examples of this as well as other establishments like the Exploratory Fisheries Project and above all by the lucrative monetary gains accrueing from catching, processing and exporting of prawns, both mechanised fishing and processing by modern methods of freezing and canning flourished beyond anybody's expectations with the result that today we have about 13,000 mechanised boats and a lakh of country crafts operating in our waters, providing gainful employment for millions of our population either directly or indirectly. With the annual average landings exceeding two million tonnes, India now ranks sixth among the fish producing countries of the world, excelled only by Japan, Peru, China, Norway and the United States.

The country has today over two hundred freezing plants with a capacity of about a thousand tonnes per day and over three hundred exporting organisations dealing in marine products which now cater to the most quality conscious, unconventional and sophisticated markets like the United States, Japan, Canada, United Kingdom, Australia and many of the European countries. The fishing and fish processing technologies obtaining in the country today are in no way inferior to those in any of the developed countries of the world and the fact that this tremendous stride has been achieved in a short span of two and a half decades speaks volumes of the possibilities that exist for future development. The export figures presented in Table 2 give some idea about the pace of this development in recent years.

TABLE 2

Export of marine products from India since 1965

Year	Quantity (Tonnes)	Value (Crore rupees)
1965	15,457	6.9237
1966	19,153	13.5246
1967	21,764	19.9286
1968	24,810	20.0846
1969	30,584	33.0731
1970	37.175	35.5359
1971	34,032	39.1725
1972	38,271	58.1317
1973	48,785	79.5763
1974	46,629	76.3127
1975	53,412	104.9063
1976	62,151	179.8620
1977	64,957	179.7000

Research in fishery technology

Since both mechanised fishing and modern methods of processing viz., freezing and canning were entirely new to the country, systematic research into various aspects of these branches of technology to suit the conditions obtaining in our country emerged as an urgent need of the hour and the Central Institute of Fisheries Technology, Cochin, was established in April 1957 with the above purpose in view, with the Craft and Gear Laboratory being set up first. Design, fabrication and demonstration of suitability to existing Indian conditions by practical field experiments of fishing crafts of various sizes and gears of different principles and materials, efforts towards their cost reduction and efficiency enhancement, their management and scientific maintenance are among matters which receive continuous and concerted concern and attention of the above laboratory. As mentioned elsewhere above, the earlier attempts at freezing of prawns were made under foreign advice and expertise and as such the scientific implications of the processes were unknown to our people. Added to this, rejections of some of the consignments of frozen prawns exported to the United States due to alleged substandard quality towards the later half of the fifties necessitated the urgent addition of a full-fledged processing laboratory towards the fall of 1958 to the one and a half year old Craft and Gear Laboratory of the Central Institute of Fisheries Technology. The bulk of the information available at present on the processing technological aspects of the Indian fishes has resulted from the researches conducted in this laboratory and its research centres. While the Central Food Technological Research Institute under the Council of Scientific and Industrial Research has made notable contributions to this field of our knowledge, some laboratories under the maritime state Governments have to a limited extent handled some specialised aspects. The results of all these efforts have goe into the status of development which our fish processing technology has achieved today, the salient features of which we may briefly review in the following paragraphs.

Handling and Preservation

This is the first step in the post-harvest technology of the highly perishable commodity, which under our tropical weather conditions demands the most dexterous treatment in order that the wastage may be reduced to a minimum. An estimated 67.9% of our total fish landings (including marine and fresh water) is consumed in the fresh condition both in and around the landing centres as well as transported to distant consuming centres by road and rail. A good deal of research effort has been expended on various aspects of handling and preservation especially with respect to the foreign exchange earner viz., prawn. Fish starts to spoil the moment it is taken out of water and it has been observed that four hours is the maximum duration of time for which it can remain in prime state of freshness at our ambient temperature conditions, when once it is taken out of its habitat. Eternal alertness and prompt action are most essential in maintaining good quality of the harvested fish. As soon as the haul is unloaded on the deck, it has to be washed free of dirt and debris and sea water from the distant open sea has been found quite safe for this purpose. In this respect, sea water from near the shore has been observed to be highly contaminated by even faecal organisms and chemical pollutants. Fish are to be sorted out next, the larger ones to be eviscerated and degilled and the prawns to be beheaded, cleaned and iced. The latter have to be preferably given a dip treatment in a 0.1% solution of sodium metabisulphite for a few minutes and subjected to ice storage without contact with atmospheric air and contamination with heavy metals like iron and copper to prevent black spot formation on the shells and the former bled properly in ice cold water. Exposure of the catch on the deck to the vagaries of atmospheric conditions has been found to affect the quality adversely, which could be avoided by stacking the iced fish in proper containers inside the fish holds so that the fish do not get crushed or squeezed under pressure from the weights of containers above, the ice melt water from which flows out without contaminating the contents of the containers at the lower layers. In smaller fishing crafts which have no fish holds, the catch has to be carefully kept in some safe corner without any inadvertent trampling or contamination from oil, grease and other possible pollutants that are usually met with on board.

Proper sanitation of the boat decks, fish holds and containers has to be ensured, as they have been formed to harbour heavy bacterial

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loads with presence of even pathogenic and faecal organisms when improperly maintained. After each fishing trip these materials have to be scrubbed free of slime, dirt, blood and any debris or fish fragments with the help of a detergent like teepol, soap or washing soda and disinfected with a germicide like chlorine. Diluted bleach liquor containing 100 and 1000 ppm of available chlorine serves the purpose in the cases of metallic and wooden surfaces respectively, after which any excess disinfectant remaining has to be flushed out with fresh potable water. From this point of view, wooden containers are not advisable for storing the fish either on board or in processing establishments, as their surfaces are difficult to be disinfected properly. When once the catch reaches the shore, it has to be expeditiously despatched to the factories in the case of those meant for processing, to the markets in the case of those meant for consumption as fresh and to the packing centres in the case of those which are to be transported as fresh iced to distant markets.

Eventhough some work has been reported in the country on the use of irradiation from a radio active source for the preservation of fresh fish, its harmlessness to human beings who consume the preserved fish is yet to be proved and approval of the health authorities for its commercial application is yet to be accorded. The efficacy of using refrigerated seawater for preservation of sardines, mackerel and prawns has been worked out and reported and the advantages and disadvantages of this method over the conventional holding in crushed ice have been discussed.

Transportation

In the earlier days fish landing centres were very difficultly approachable, only limited quantities being moved by head or bicycle loads to nearby places and large quantities having at times to be diverted as manure for coconut trees when weather conditions were unfavourable even for our hereditary method of preservation by salt curing. All the maritime states are now making concerted efforts to make approach roads to the main fish landing centres so that expeditious transportation of the highly perishable commodity can be effected by quick means of transportation like lorries and trucks. Much remains yet to be achieved even in this respect by way of proper and careful handling, sufficient and correct method of

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icing, rational loading etc. often filling the vehicles to dangerous heights more than sufficient to crush the fish at the bottom layers and without proper and sufficient mixing with ice. Bulk transportation in trucks, slowly gaining popularity throughout the country and carrier launches as practised in Maharashtra-Saurashtra region has to be carried out either employing small containers stacked one above the other without subjecting the fish to any pressure or by horizontal partitioning of the fish holding space so as to avoid crushing of the bottom layers by the weight from above.

Large quantities of fresh iced marine fishes are at present transported from Gujarat coast to Bombay by road, rail and carrier launches, from Veraval to Ahmedabad and Delhi by rail, from Ratnagiri to Bombay by carrier launches, from Andhra and Orissa coasts to Calcutta by rail and fresh water fishes from reservoirs and other sources in Tamil Nadu and Andhra Pradesh to Calcutta by rail. The containers employed are invariably disposable split bamboo baskets in the south and reed or 'harhar' baskets and plywood boxes (second hand teachests) in the north. The method of packing in the baskets consists of a lining with dry leaves inside and an outer wrapping with gunny for both baskets and boxes and leaves much to be desired as most of the times, the fishes reach the destination in a substandard quality. An All India Co-ordinated Research Project on Transportation of Fish initiated by the Indian Council of Agricultural Research during the IVth Five Year Plan with Veraval and Kakinada as despatching centres and Bombay and Calcutta as receiving centres has contributed considerably to our knowledge in this field. Expanded polystyrene slabs of different thicknesses sealed in polythene sheets have been used as insulants in most of these studies and second hand teachests as containers, both being used repeatedly. It has been demonstrated that fresh iced fish can be transported in these containers in prime condition by rail or road from Veraval to Bombay and by rail from Veraval to Ahmedabad, Delhi and even Calcutta with a reicing at Delhi. Frozen blocks of fish packed in the above containers were successfully transported by rail from Cochin to Calcutta with one transhipment at Madras and without any additional care like re-icing enroute. Same containers have also been

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employed for transportation of fresh iced and frozen fish from Kakinada to Calcutta and Delhi and fresh iced fish from Kakinada to Bombay via Hyderabad. A returnable, insulated and dismantable galvanised iron container has also been designed, fabricated and successfully field tested by transporting iced and frozen fish from Kakinada to Delhi and Calcutta and from Paradip to Calcutta. Cheaper insulating materials like boards from coconut pith and rubber latex as well as bagasse and urea formaldehyde resin have also been successfully developed. Several consignments of iced and frozen fish packed in second hand teachests with multi-layer gunny sealed in polythene sheet have also been successfully transported from Kakinada to Calcutta and Bombay (via Hyderabad)

Eventhough the Indian Railways had pressed into service some years back about half a dozen refrigerated rail wagons on selected routes for carrying fish, somehow the experiment has not caught up momentum as expected. A limited number of refrigerated and insulated trucks are employed by some of the prawn processors for transporting iced raw material from landing centres to processing factories and frozen products from factories to shipping sites. One practical difficulty faced by such transport vehicles is that they have to run empty on the return journey as the fishy odour taken up by them is imparted to any other perishable item like vegetables if carried in them. This problem has been successfully solved by oxidising the odoriferous compounds with a solution containing 100 ppm of available chlorine after an initial cleaning with a detergent for removing visible dirt, flushing with potable water, spraying with a 50 to 60 ppm sodium thiosulphate solution to remove any excess of chlorine and again flushing with potable water. Eventhough dry ice and liquid nitrogen have been employed to a large extent in developed countries for supplementary cooling of the already chilled or frozen fish during transportation, they are practically unknown in our country, eventhough the former is being used to a limited extent in transportation of frozen prawn products from factories to shipping sites involving long distances.

Freezing

As mentioned elsewhere above, this was the first sophisticated method to be employed by our fish processing industry for prawns and played the key role in modernising it. Indeed it has become a synonym for our

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present day fish preservation industry and its importance becomes evident when we know that 97.07% of the export value of Rs.179.9 crores in 1976 was constituted by frozen products, which include prawns, froglegs, lobster tails, fish and cuttle fish. Frozen prawns alone accounted for 89.34% of the exports value-wise and during the course of the phenomenal progress recorded by this industry in the rather short span of two and a half decades, it encountered several teething troubles in the form of technical problems, all of which found satisfactory solution at our technological research laboratories. The various stages of the processing technique were critically studied including the pros and cons of each step involved, tracing out all possible lacunae/ sources of error that contribute to deterioration/unsatisfactory quality of the finished product and advice rendered free of cost to the processors so that dependence on imported technical know-how was completely done away with. These studies squarely brought out the need for careful handling of the raw material, use ofpotable water (containing 1 ppm of available chlorine and less than 100 microorganisms/ml) at all stages ofprocessing, importance of using ice prepared out of water of the above quality only and handled carefully and above all for observing strict hygienic standards of holding vessels, freezing trays, processing table surfaces and personal hygiene of the workers handling the material.

The industry was at one stage taken unawares when Australia, our main market for cooked frozen prawns all of a sudden imposed strict bacterial standards for it. Our technologists lost no time in working out the most ideal conditions for turning out a product well conforming to the standards laid down by the importers and thus avoided a crisis. Thaw drip loss which occurs to the extent of 5% in headless, 10% in peeled and deveined and 3% in cooked frozen prawns used to be a cause of considerable national loss by way of the excess quantities that had to be packed in order to avoid short weight conditions at the destination. This problem has been successfully solved by treating the prepared material with the required quantity of a 16% solution of a mixture of three parts of sodium tripolyphosphate and one part of potassium dihydrogen phosphate immediately before freezing.

Frogleg, though not of marine origin, is reckoned as a seafood as it is frozen and exported along with other marine products. A record quantity of 3170 tonnes of this commodity worth Rs.7.8 crores was exported in the year 1976. Starting from a method evolved for painless cutting of legs from live frogs (after narcotising them by a dip in 10% common salt solution for 10 minutes), technology has been perfected for the most hygienic way of freezing of this material. This industry was faced with a serious crisis in 1974 when considerable quantities of the frozen product were detained in U.S. ports due to detection of the pathogenic organism, 'Salmonella'. Though the products had been tested and found perfect at this end by the same methodology as adopted by the U.S. Food and Drug Administration, the latter unilaterally changed their method of sampling resulting in the detection of these organisms in some of the consignments. Our research laboratories lost no time in improving upon our processing techniques, using common salt and chlorine solutions of adequate strength at various stages and adopting the FDA's sampling technique so that not even a single sample would escape detection of the organism if any, enabling regeneration of our once threatened trade with the U.S. in this commodity and resulting in the record performance in 1976. The wastes or offal from this industry can also be gainfully converted into a frog meal for poultry feed and an oil with potential therapeutic value can be salvaged from the offal.

Freezing of lobster tails, fish and cuttle fish for export has not posed much of a problem, even though the latter two products have picked up momentum only in the last couple of years and the former is about two-thirds as old as our freezing industry. However with all this development, the quantity of fish utilised for freezing in our country works out to only about 5% of the total landings and that too goes almost entirely for the export trade. There is plenty of scope for freezing and holding in frozen storage of many of our quality table fishes so that their availability round the year can be improved and they can be distributed over a wider area ensuring better returns to the fishermen by their more efficient and economic utilization. Quantity-wise oil sardine ranks top most among our marine fishes, contributing even one-third of the total landings in some years, proper handling and utilisation posing serious problems in glut seasons. Properly

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frozen blocks with sufficient glazing, the fish keeps in good edible condition for upto five months depending upon the fat content, to which the shelf life appears to be inversely proportional. Ice storage of the raw material adversely affects the shelf life of the frozen product. Belly bursting, a serious problem occurring in some seasons in iced as well as frozen and thawed sardines has been successfully overcome by a pre-dip treatment of the raw material for 30 minutes in 15% brine, which also imparts a better appearance and firmer texture to the fish.

Pomfret, a highly relished table fish of our country and constituting a substantial fishery on the Maharashtra-Saurashtra coasts, quick frozen in blocks, glazed with a solution of 2% ascorbic acid containing 0.2% citric acid and packed in polythene lined gunny bags remained in excellent edible condition for 9-12 months at -15 to -18°C, yellow discolouration and dehydration occurring considerably in the absence of the above precautions. Another of our important marine fish viz., mackerel, frozen and glazed with a solution of sodium chloride and glucose remained in good condition for more than six months in frozen storage. Seer, tuna, tilapia, Bombay duck, mussels, clams, squid and crab are among some of our other table fishes and shell fishes which have been studied with respect to their frozen storage characteristics and observed to keep well for reasonable periods under such conditions.

Canning

This is the second in importance of the modern methods of preservation to be employed by our fish processing industry and that too mainly on prawns. Initiated in the year 1959 with a modest export of 373 tonnes worth Rs.23 millions, the industry quickly picked up momentum until the record quantity of 2199 tonnes worth Rs.5.24 crores was exported in the year 1973 and thereafter faced a steep fall to a mere 102 tonnes worth Rs.39 lakhs in 1976. The reasons for this set back are many, the most important being the lack of demand for the commodity in the world market. The greater demand for frozen shrimp with consequent increase in purchase price of the raw material as well as the high cost of the imported tin container in our country have also contributed to this decline in the industry.

Detailed research work has been carried out on standardisation of the different steps involved in the processing of this material. Concentration of blanching brine and blanching time are the most important factors controlling drained weights in canned prawns, while acidity and volume of the filling brine, time of cooling of the blanched meat and processing time affect the drained weights to varying extents. Blackening of the can interior and contents has been a major defect encountered at one time in the product resulting in detention of considerable quantities at the time of pre-shipment inspection, which has been shown to be due to formation of copper and iron sulphides from the hydrogen sulphide released from the sulphur containing amino acids and the metals which contaminate the material during processing. While blackening caused by iron could be controlled by maintaining proper acidity in the filling brine, that due to copper could not be prevented by any chemical treatment, but only by scrupulously avoiding copper coming into contact with the material at any stage of processing.

Sanitational qualities of water and ice used in processing operations, utensils andother surfaces coming into contact with raw and blanched meat and factory environs and personnel have been observed to be important factors controlling sterility in canned prawns and none the less the exhausting and processing times and the conditions of the seams. Gram positive spore-formers of the Bacillus type like _B. pantothenticus_, _B. firmus_, _B. brevis_ and _B.pumilus_ have been found to be the major micro organisms responsible for causing spoilage in canned prawns, their main source being can cooling water, while gram positive _cocci_, rods, non-spore forming rods and _coccoids_ are to a lesser extent causative of the above malady. Attempts at mechanisation of at least some of the steps of the prawn canning process have been made and design and fabrication of an automatic brine dispenser which delivers measured quantities of hot brine into cans filled with blanched meat and passing under the dispenser on a conveyor belt and a brine-o-meter which directly reads the concentrations of blanching brine based on the principle of electrical conductivity have been perfected successfully.

The canning method of preservation has been applied to some extent in our country on mackerel, sardine and tuna, mostly for supply to

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the armed forces, partly for the internal civilian market and to a small measure for export to other countries. Various steps in the processing of these fishes have been standardised to perfection and all the informations are readily available. Maximum period for which fresh mackerel can be held in ice prior to canning without materially affecting the quality of the product has been determined to be three days. Processing details for canning of mackerel in different media like brine, oil, tomato sauce and curry in different sizes of cans and the effects of period and temperature of storage and incorporation of antioxidants on the quality of the canned product have been studied and reported.

Sardines can be preserved in ice for a period of two days prior to canning without substantially affecting the quality of the canned product. Methods for canning sardines in their own juice (called 'natural pack' with a view to reducing cost of processing), tomato sauce, maiyonnaise sauce, curry etc. have been standardised. Eventhough we have got the highest landings of this fish among all our marine species, we have not yet been able to make an impact on the international market for canned sardines due to the high cost of the filling medium (edible oil), non-availability of the internationally popular medium viz., olive oil in the country and the high cost of the imported tin plate, in spite of the fact that the Government of India is now offering 20% of the f.o.b. value of the commodity as subsidy.

Out tuna fishery is concentrated around the Lakshadweep Islands and naturally the tuna canning industry has got established there. Canning conditions for silver and black pomfrets and hilsa have been worked out and reported. Silver pomfrets could be held in ice for five days and the other two for three days prior to canning. Canning of seer fish, lactarius, tilapia and dara has not been practised widely in our country although the technical knowhow for it has been worked out and reported. Since there is a good demand for canned froglegs in the foreign markets, a method has been perfected for the process; butit is yet to pick up commercial application. One method of economic utilisation of the comparatively cheaper eel fish is to smoke and can it, a method for which has been worked out and reported. Investigations are in progress for standardization of the methods of canning of our important shell fishes like clams, mussels, oysters, crab and squid.

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Salting, Curing, Dehydration:

As pointed out earlier, eventhough this was our earliest method of preservation of fish, it is perhaps the most neglected one at present. Being the cheapest method and hence the most potential one to suit the pockets of the poorer sector of the population, this is bound to remain one of the important methods of preservation especially in the developing countries for quite a long time to come. An estimated 21% of our total fish landings is subjected to this method of preservation. Though dried shrimp occupied the pride of place among our export items in the pre-independence era, its contribution towards our exports in 1976 was a mere 36 tonnes worth ₨.3.85 lakhs. In this respect dried fish fared better in the same year exporting 4668 tonnes worth ₨.1.73 crores. Considerable quantities of the latter product are consumed in the internal markets. There is vast scope for introducing a little amount of sophistication in this sphere of our industry by performing the preparation, processing and packaging in a more scientific andhygienic way so that theproduct becomes more presentable and appealing to the eyes of the buyers and the shelf life gets enhanced, increasing the possibilities of wider distribution over longer periods and hence ensuring better economic returns to the fishermen. This may also open up new avenues of export even to the sophisticated western markets.

Smoking of the salted fish prior to drying imparts an attractive flavour to the product. Devices for hygienic and artificial drying of salted fish like single and multideck tunnel dryers as well as dryers utilising solar energy have been designed and prototypes fabricated already. A couple of such dryers have also gone into commercial production in our country. Preservative mixtures containing refined salt, sodium propionate and butylated hydroxy anisole have already been developed and recommended to be dusted on cured anddried fish for warding off fungus and red halophylic attacks and controlling development of rancidity, which are by far the most widely encountered spoilage symptoms occurring in such products. A vast amount of research effort has been expended on the various aspects of this method of preservation of fish in our country and the information available on them is considerable. 'Massmin' from tuna and colombo cured (pickled) mackerel were two of our famous products deserving special mention belonging

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to this category at one time. Some amount of research work has also been carried out in our country on the latest method of dehydration viz., accelerated freeze drying as applied to fishery products. The method works well with lean fishes and shell fishes. Blanched prawns as well as cooked and flaked lean fishes and ready-to-serve preparations out of them lend themselves well to this method.

Quality Control and Inspection

Realising the importance of this industry in the Nation's economy, the Indian Standards Institution has formulated quality standards (Indian Standard Specifications) covering a multitude of items like *fresh* silver and brown pomfret, threadfin, mackerel and seer fish, *frozen* prawns, froglegs, lobster tails, threadfin, silver and brown pomfrets, mackerel, seer and cuttle fish, *canned* pomfrets in oil, prawns in brine, mackerel in oil and brine, sardine in oil and its own juice, lactarius in oil, tuna in oil, crab meat-solid pack and in brine, *dried* prawns, white baits, laminated Bombay ducks, dry salted mackerel, seer, shark, tuna, threadfin, jew fish, cat fish, chorinemus, horse mackerel, shark fins and fish maws. Specifications have also been made for hygienic conditions in canning industry, for maintenance of cleanliness in fish industry, for fish meal as live stock feed, shark liver oil for veterinary use, sardine oil, basic requirements of fish stalls and fish markets and for master cartons for export of frozen seafoods and froglegs. A glossary of important fish species of India and a procedure for measuring temperature of quick frozen foods also have been drawn up by the Indian Standards Institution. Adopting the salient features of the Indian Standards, the Government of India (Ministry of Commerce) have introduced compulsory preshipment inspection for frozen and canned shrimp from March 1965, frozen froglegs from March 1966, shark fins and fish maws from January 1970, frozen lobster tails from December 1971, for bacterial quality of cooked frozen prawns and commercial sterility in canned products from 1968, bacterial quality of raw frozen shrimp - total plate count from January 1974 and others from August 1973 and canned crab meat from February 1977. A system of continuous inplant inspection is also to be introduced immediately in this industry, which will further ensure better quality and instill confidence in the importers about the reliability of our products. A good deal of research effort at

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more than one laboratory has gone into the drawing up of the scientific details required for formulating the above standards as well as maintaining strict hygienic standards right from the point of catching on board fishing vessels to the final processing and packaging stage.

Utilisation of the less popular varieties of fish

Not all the fish caught in the trawl nets are equally popular or readily disposable in the fresh state. An All India Co-ordinated Research Project is already in progress for finding out ways and means of better utilisation of these less popular varieties of fish so as to render the fishing industry economically more viable. A method has already been worked out for preparation of a colourless and odourless fish protein concentrate in dry powder from suitable for human consumption from some varieties of these fishes, which can be incorporated with wheat flour in chapathis, bread, biscuit and a host of other similar preparations. A bacteriological peptone suitable for microbiological culture studies and comparable to the best imported brand of the material has been developed from some of these varieties of fishes. Edible meat picked from these mixed varieties with the help of a machine and frozen in blocks as fish 'kheema' has been found to be popular as cutlet base as well as for incorporation in several products like fish soup powder, fish wafers, fish spirals, fish jams, fish sausages, pet foods etc. either as such or after partial hydrolysis and deodourisation. Beverages incorporating hydrolysates from the meat of these fishes have been developed on the lines on which vegetable proteins are being utilised for the purpose. Technical know-how has been worked out for converting such varieties of fishes as well as offal from fish processing industry into fish meal for poultry and cattle feed as also an ensiled product employing lactic acid fermentation which can either be fed to cattle etc. as such after neutralisation or incorporated into materials like rice bran to prepare a dry feed mix. These fishes also lend themselves well for salting and drying in which form they can easily be transported and distributed in the protein starved high ranges and tribal areas.

Utilisation of byproducts

Considerable progress has been achieved in scientific and economic utilisation of the byproducts of the fish processing industry. An estimated 40,000 tonnes of prawn heads and shells are thrown out of the freezing and canning factories per annum. A small portion of it is being cooked, dried and powdered for manure and poultry/cattle feed. An integrated process has now been developed for extracting a protein concentrate in paste form, isolating valuable chemicals like cholesterol and glucosamine hydrochloride and for converting the chitinous material left over into chitosan which finds varied industrial applications like sizing of textiles, clarification of wine, purification of water and as a general industrial flocculant. Another valuable product of the fishery industry viz. sardine oil has been utilised for preparation of factice (an artificial rubber filling compound), as a base for printing ink and paints, as a lubricating oil after necessary treatment and as a source of highly unsaturated fatty acids having potential pharmaceutical applications. The oil also possesses the property of reducing the cholesterol content of the blood of animals fed with it.

The maritime states of the country have set up factories for extracting shark liver oil as a natural source of vitamin A. Fish body oils are used either as soap stock or sulphonated for fat-liquering in the leather tanning industry. A methodology has been worked out for isolating the rays from shark fins which have got better demand in the importing countries.

Conclusion.

A glance at the export figures of fishery products from India in 1976 shows that shrimp in the forms of frozen, canned and dried constituted 89.56% of the entire export value, frozen alone accounting for 89.34% and that the major portion of the exports was to Japan and the United States. Frozen shrimp, froglegs, lobster tails, fish and cuttle fish constituted 97.07% the export value. These facts indicate an over-dependence on three factors: (1) one particular commodity viz., prawns, which constitute only 10-12% of our total marine fish landings, (2) one method of processing viz. freezing and (3) just two major marketing avenues mentioned above. In fact freezing of the above mentioned commodities has become the main-stay of our fish processing industry of late. This is a very unhealthy trend followed by the industry, eventhough the two new items added to the list in the last couple of years viz., fish and cuttle fish have shown encouraging results. It may be noted that in spite of all these, nearly 50% of our installed freezing capacity is lying idle. Application of the technology already worked out for freezing preservation of our other important food fishes for internal consumption is sure to go a long way in the alround development of the industry. The present day condition of our canning industry is more distressing. With the steep fall in demand for canned prawns from abroad, most of our canning plants prefer to remain closed. They can very well make use of the technical know-how and idle processing capacity already available for preserving our many valuable food fishes with a view to ensuring their more even and economic distribution/utilization. The attitude of our entrepreneurs towards the multitude of industrial/speciality products developed by our research laboratories also has not been encouraging in so far as their commercial exploitation is concerned. It has also to be pointed out regretfully that fresh water fishes which constitute about one-third of our total fish landings have not received a square deal at the hands of our technologists.

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FISHERY RESOURCES OF INDIA

B y
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Introduction

In the history of world fisheries, focussing of interest in the Indian Ocean Fisheries, particularly in the Arabian Sea and the Bay of Bengal bordering India, is comparatively a recent development which has stemmed from the efforts made by countries like India to step up the supply of protein to its large populations. It is an accepted fact that the countries bordering the Indian Ocean are the most thickly populated. About a quarter of the world's population lives in these countries, largely in low nutritional standards in terms of calories and acute deficiency in terms of animal protein. While fairly good statistics on fish production are available for Australia, South Africa and India, only rough estimates are available for Ceylon, Pakistan and Malaysia. Though the estimated potential of marine fishery resources of the Indian ocean is about 10 million tonnes, the continental shelf area around India is estimated to support about 3 million tonnes of fish despite the fact that the present production is only to the tune of about 1.39 million tonnes.

Inland fisheries

Accurate statistics on fish production, both inland and marine, are of vital importance in assessing the fish stocks and also in formulating fishery developmental projects. In India, the collection of basic data on inland fish production is handicapped by various factors such as the highly dispersed and isolated nature of fishing and landing areas, the diversity of fishing gear and tackle employed, a high percentage of subsistence fishing, the innumerable landing centres, the migration of fishermen from one place to the other for fishing, the disposal of the catches to fish mercants from the fishing boats at the fishing spots, the multispecies composition of the catches, the landing of catches in unsorted condition and the limited nature of transport facilities for making direct observations at lower estuaries and remote landing centres. Besides the above

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the vast expanse of the fresh and brackish water areas in India poses additional problems as far as the estimation of fish production is concerned. It is estimated that the main rivers of India including their important tributaries have a total length of about 27,000 km, a network of canals and irrigation channels extend to over 112,000 km, the lakes and reservoirs cover an area of about 2.9 million ha. and freshwater ponds and lakes extend to about 1.6 million ha. A sampling technique that has proved to be effective in the estimation of total landings, such as the Hooghly-Matlah estuarine system and River Godavari, is that based on the relation between actual catch and effort potentialities in a region, which requires a total enumeration of effort potentialities in the form of craft, tackle and fishermen population in the entire region as a prerequisite. However, the multiplicity of gears in use involving both inter and intra-type variations create additional problems in estimating the total effort.

In view of the various practical difficulties in estimating the inland fish production in India, either the annual marketable surplus furnished by the States or one-third of the marine fish production until 1965 and half of the marine fish landings during the subsequent years are generally considered as fairly reasonable criteria for computing the inland fish production. On the basis of the above, the inland fish production in India was estimated at about 200,000 tonnes in 1951 and over 860,000 tonnes in 1975-76, registering almost a four-fold increases (Table.1). As seen from the available statistics for 1975-76, out of the 860,000 tonnes of inland fish, West Bengal accounted for 260,000 tonnes, Tamil Nadu 175,000 tonnes, Andhra Pradesh 100,000 tonnes, Bihar and Karnataka about 65,000 tonnes each and Kerala, Orissa and Uttar Pradesh 25,000 tonnes each. Among the major varieties of freshwater fishes supporting the fishery are carps, cat fishes, lung fishes, prawns, feather backs, mullets, eels, herrings and anchovies.

Table.1. Production of inland fish in India from 1961-62 onwards

	(000' tonnes)
1961-62	269.8
1962-63	261.4
1963-64	314.8
1964-65	412.3
1965-66	458.3
1966-67	473.4
1967-68	533.3
1968-69	616.8
1969-70	646.2
1970-71	659.1
1971-72	683.6
1972-73	734.5
1973-74	784.1
1974-75	803.8
1975-76	862.7

Fifth Plan targets 1055.0 (1978-79)

Marine Fisheries

The marine fishery resources amounting to almost thrice those from the inland waters in India constitute the main stay of the fishing industry in the country. India, with a coast-line of about 5,600 km and over 2000 fishing villages spread over the east and west coasts has about 1300 landing centres where marine fish caught by indigenous crafts as well as larger mechanised vessels are landed throughout the day and even at night round the year. As such, collection of marine fishery statistics, so vital for the assessment of stocks of commercially important varieties of marine fishes, management of the fishery and proper exploitation of the resources, has been an uphill task. Until 1947 when the Central Marine Fisheries Research Institute was established, there was practically no machinery in the country to collect reliable marine fishery statistics on scientific lines although a few State Fisheries departments used to compute the marine fish landings from the amount of salt issued to fishermen at subsidised rates through the fish curing yards and also from the royalties received from the fishermen and fish merchants. The start for a well planned marine fishery resources survey was made in 1948-49 by the Fishery Survey and Statistics Division (now renamed as Fishery Resources Assessment Division) of the CMFRI when a pilot survey was conducted all along the coast for collecting basic data on the number of fishing villages, the population of fishermen actively engaged in fishing, the actual area exploited, the various types of crafts and gear employed, fishing seasons, various types of fishes caught, etc. The problem of collecting marine fishery statistics being a complex one, a suitable sampling design involving space-time stratification was carefully worked out. The entire coastline was divided into 57 homogeneous survey zones and well trained personnel posted in the different zones for collecting relevant data not only on catch and effort but also on certain biological aspects essential for studying the size and age composition of the more important varieties of fishes. Besides the above, a system of reporting on the special features, trend of the fishery and price statistics at the landing centres was also started. Quinquennial frame Surveys are also conducted in order to study the changing patterns, if any, in the fishing activities in the different zones. Special surveys for collecting statistics on lobster landings and catches landed by mechanised boats at certain centres where there is concentration of mechanised boats are also conducted. The Fishery Data Centre of the Fishery Resources Assessment Division of the CMFRI is responsible for the compilation, analysis and dissemination of the processed data to the industrialists, Central and State Fisheries departments and other National and International agencies.

Marine Fishery Resources

From the unpublished report it has been observed that the total marine fish landings in India amounted to only 0.45 million tonnes in 1949, whereas those in 1976 have been estimated at 1.39 million tonnes recording almost a three-fold increase. However, it may be stated here that published figures on the marine fish production in India are available only from 1950 onwards. From Table 2 it could be seen that during the 20-year period between 1950 and 1969, the total marine fish production varied between 580,000 and 900,000 tonnes though the fishery had its own viscissitudes during certain years. The total marine fish landings crossed the 1 million mark in 1970 and continued to be so except during 1972 when there was a general set back in the fishery.

TABLE 2 - Marine fish catches in India from 1950 to 1976

Year	Catch (tonnes)	Year	Catch (tonnes)
1950	580,022	1964	859,582
1951	533,916	1965	832,777
1952	528,348	1966	890,311
1953	581,463	1967	891,888
1954	588,258	1968	934,611
1955	595,725	1969	913,630
1956	718,779	1970	1085,607
1957	875,516	1971	1161,389
1958	755,994	1972	980,049
1959	584,587	1973	1220,240
1960	879,681	1974	1217,797
1961	683,569	1975	1422,693
1962	644,244	1976	1394,010
1963	655,484		

State-wise Landings

Although the trend of marine fish landings in India has generally been towards an increase, the fluctuations noticed during certain years have been largely dependent on the success or failure of two of the most important pelagic fisheries, viz., the sardine and mackerel fisheries. Analysis of landings in the various coastal zones indicate that west coast of India flanked by the Arabian Sea accounts for nearly three-fourths of the total fish landed, the major components being the various types of sardines (25%) among which the Indian Oil Sardine *Sardinella longiceps* is the most valuable, the Indian mackerel *Kastrelliger kanagurta* (11%) and prawns (15%). Among the maritime States in India,

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Kerala occupies the first place (35%) followed by Maharashtra (17%) Tamil Nadu (15%) Gujarat (9.8%), Andhra Pradesh (8.8%) Karnataka (8.2%), Goa (2.4%) West Bengal and Orissa (2.0%) and the Union Territories of Andamans and Lakshadweep together contributing to less than 1%. Sea fisheries are particularly important in the states of Kerala, Karnataka, Maharashtra and Gujarat along the west coast and the average landings per fisherman per annum are about 5 tonnes as compared to less than 1 tonne in the states of Tamil Nadu, Andhra Pradesh, West Bengal and Orissa along the east coast. However, there are possibilities of substantial increase where new fisheries are developed. The Gujarat coast is well known for its rich fishery for Bombay duck (Harpodon nehereus) which, in dried form, has an important export market and the pomfrets which are top class table fish all over India. The prawn fishery in the Gulf of Cutch area hold out promise for high yields. The Maharashtra coast is rich in prawns, pomfrets, Bombay duck and the Indian Salmon, popularly known as the Rawas and Dara. Along the coasts of Karnataka and Kerala the Indian mackerel Rastrelliger kanagurta and oil sardine Sardinella longiceps occur in extensive shoals. Prawns also form an important fishery in these areas. In the Kerala region, the mechanised boats have opened up new fisheries like that of the Kalava or perches in the Wadge Bank area. Around Cape Comorin andalso on the Coromandel coast of Tamil Nadu are considerable quantities of seer fish and miscellaneous varieties formed of variouspercoids and trichiurids. Several species of sharks and rays yielding considerable quantities of liver oil are found along the east and west coasts of India. Andhra Pradesh and Orissa coasts support good fisheries for miscellaneous groups of sardines, percoids, sharks and to some extent prawns. Fairly large concentration of prawns, percoids and other groups of smaller fishes occur towards the head of the Bay of Bengal. While the production of pelagic fish exceeds that of demersal fish in the States of Karnataka, Kerala, Goa, Andhra Pradesh and West Bengal, a reverse relationship exists in the States of Gujarat, Maharashtra and Tamil Nadu which gives a fair indication of the distribution pattern of the two groups of fishes along the east and west coasts of India. The State-wise marine fish catches during 1976

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and the dominant varieties supporting the fishery are shown in Table 3.

Mechanisation

About three decades ago there was hardly any mechanised fishing in India and the reliance was on fishing with indigenous craft and gear in the inshore waters. The rapid strides made in mechanisation, particularly during the last two decades, have been phenominal resulting in the extension of the fishing activities upto 50 or even 75 metre regions off the east and west coasts of India. The progress made in mechanisation can be better understood from the details given in Table 4. The total number of mechanised boats in operation during the last year of the IV Plan (1973-74) itself was 10,613 and the target during the V Plan (1974-75 to 1978-79) is set at 15,498, the achievement during 1975-76 itself being 12,333. Among the maritime States, Maharashtra leads with 2,993 mechanised boats in 1975-76 followed by Gujarat (2,463) Kerala (2,300), Tamil Nadu (2,300) and Karnataka (1,290).

TABLE 3. STATEWISE MARINE FISH CATCHES DURING 1976*

Sl. No.	Name of State	Total Catch	Dominant Varieties
1.	West Bengal	25,411	*Thrissocles*, *Harpodon nehereus* Sciaenids, Ribbon fish, Penaeid Prawns, Non penaeid prawns
2.	Orissa	29,823	Elasmobranchs, Cat fish, Lesser sardines, Pomfrets, Seer fish, Penaeid prawns.
3.	Andhra	1,31,321	Elasmobranchs, Lesser sardines *Anchoviella*, Sciaenids, Ribbon Fish, penaeid prawns
4.	Tamil Nadu	2,26,078	Elasmobranchs, Lesser sardines Sciaenids, Ribbon fish, *Leiognathus*, Mackerel
5.	Pondicherry	10,123	Lesser sardines, *Thrissocles* Sciaenids, Ribbon fish *Leiognathus*, Mackerel
6.	Kerala	3,31,047	Oil Sardine, Cat fishes, Lesser sardines, *Anchoviella*, Mackerel, penaeid prawns

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7. Karnataka	95,283	Cat fishes, Oil sardine, Sciaenids, Leiognathus, Mackerel
8. Goa	34,968	Lesser Sardine, Oil sardine, Sciaenids, Mackerel, penaeid prawns.
9. Maharashtra	2,93,611	Harpodon nehereus, Sciaenids Ribbon fish, Pomfrets, Penaeid prawns, Non penaeid prawns
10. Gujarat	1,71,294	Elasmobranchs, Harpodon nehereus Sciaenids, Ribbon fish, Penaeid Prawns, Non penaeid prawns
11. Andamans	1,334	Anchoviella, Perches Caranx, Leiognathus
12. Lakshadweep	2,572	Elasmobranchs, Perches Caranx, Tunnies

*Extract from the provisional estimates arrived at by the C.M.F.R.I.

Table 4. Progress of mechanisation of fishing boats in the different States during the last year of the IV Plan, targets during the V Plan and achievement during 1975-76

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States	Last year of IV Plan 1973-74	Fifth Plan Targets 1978-79	Achievements during 1975-76
1. Gujarat	2000	3000	2463
2. Maharashtra	2913	3238	2993
3. Karnataka	1100	1302	1290
4. Kerala	2014	3504	2200
5. Tamil Nadu	1800	2800	2300
6. Andhra Pradesh	240	400	298
7. Orissa	122	300	160
8. West Bengal	5	105	52
Union Territories			
9. Andamans	2	52	--
10. Goa	168	243	207
11. Lakshadweep	113	233	144
12. Pondicherry	131	321	206
Grand Total	10,613	15,498	12,333

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Mariculture

One of the most significant developments in the recent years has been the application of improved techniques in coastal aqua-culture or mariculture with a view to stabilising the production through marine capture fisheries which have often been plagued by large scale fluctuations and uncertainties. Though aquaculture has been in vogue in many of the developing countries, the advanced techniques developed in the recent years in respect of culture of different varieties of fishes and prawns have gone a long way in increasing the production multifold. Attempts made in culturing lobsters, mussels and economically important seaweeds have yielded encouraging results. Culture experiments carried out by the Central Marine Fisheries Research Institute include saltwater fish culture at Mandapam, prawn culture at Narakkal and Kovalam, mussel culture at Vizhinjam, Kozhikode and Kovalam, lobster culture at Kovalam and seaweed at Mandapam.

Newer resources

From the point of view of demand for and supply of certain marine products which have hitherto remained unexploited or under-exploited, there has been a spurt in the diversification of fishing activity aimed at increasing the production of newer resources such as cephalopods (mostly cuttle fishes and squids) whose production has increased ten-fold during the last one and a half decades. Large concentrations of myctophids which are rich in Vitamin 'A' content have been reported to occur along the upper continental slope off the west coast of India. Among the demersal fishery resources of the continental edge of the soughwest coast as well as the east and northwest coast of India the swaming crab Charybdis (Goniohellenus) forms an important constituent. Similarly, the occurrence of large quantities of deep-sea gastropod Pirula investigatoris, deep-sea echinoid Elipneustes denudates and several varieties of deep-sea fishes and crustaceans along the upper continental slope off the south-west coast of

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India has been reported. It is needless to mention that the development of technologies for the proper exploitation of the above mentioned resources as well as the pelagic oceanic fishery resources such as tunas and related species, bill fishes, pelagic sharks, sauries, flying fishes, oceanic squids, marine turtles, whales, dolphins and porpoises deserve top priority while formulating the marine fisheries developmental plans for the rational utilization of the marine resources in the new 200 mile economic zone.

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A GENERAL ACCOUNT ON THE FISHING GEAR AND METHODS

By

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Fishing and hunting can be traced to the same origin but opinion differs whether fishing is older or vice versa. Fishing like Agriculture is a form of primary production and the technique of fishing includes the method as well as the gear employed. Eventhough in relation to the world catch only a few methods are of interest namely trawling, purse seining, gill netting and lining there are other methods too by which fishing is done and therefore cannot be neglected, though localised and periodical. To understand all these methods and gear it is necessary to collect the details of practices of catching techniques from all over the world. Von Brandt has classified fishing gear into the following 13 categories taking into consideration of the various fishing gear and techniques from the different parts of the world.

1. Fishing without gear:

This is primarily a method of hand picking. Sometimes baskets or small tools for gathering fishes are also used which are not considered as gear.

Fishing by feet is also another method. Diving is a general practice. Trained birds or animals are also used.

2. Stupefying methods:

This includes the use of underwater explosion, poisoning with ichthyotoxic plant preparations and by electric current.

3. Wounding gear:

Spears, harpoons of different types, so also clamps, tongs etc. and guns form the devices.

4. Lines:

Lines can be with or without hooks, the main principle in this method is to offer a real fish or artificial bait to entice the fish to bite. Various forms of hooks are used in angling. Different types of lines are cast lines, hand lines, pole and line, set and drift lines and troll lines.

5. Traps:

Trap is a place to which the fish is lured by a bait or attracting device and caught by special arrangements. Traps can be natural or artificial shelters like artificial reefs, bundles of brush wood, tubes etc. or mechanical traps like gravity traps, box traps, torsion traps etc. and snares.

Traps for jumping fish: Certain fishes jump out of water when excited or in danger. Making use of this behaviour artificial obstacles such as hedges, wall nets etc. are made to make the fish jump and it is then collected. To cite a few examples are salmon traps, boat traps, verandah nets, scoop nets, pit fall traps etc.

6. Bag nets:

Bag nets are with totally or partially framed mouths which can be fixed or mobile. The opening of the mouth of the net is effected by the water flow and fishes are filtered. The most developed bag net is otter board stow net. Other examples are scoop nets, push nets, drag nets, scrape nets, gape nets etc.

7. Dragged gear:

These are nets towed through water. Ex: Rakes, dredges, trawls.

8. Seine nets:

Here one end of the net is shot from a fixed point to cover an area and then turned to the starting point where the gear is hauled up. The starting point can be shore or boat seine nets. This can be with or without bags.

9. Surrounding nets:

Here a fish shoal is enclosed and scooped. The bestknown example are ring nets and purse seines.

10. Dip nets:

This includes all types of nets which are lowered down and lifted up from the bottom, called either dip or lift nets. The other examples are fish wheels.

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11. Falling nets:

This type of gear falls over the fishes and cover them. This includes cover pots, cast nets etc.

12. Gill nets and tangle nets:

Now we will discuss the different kinds of gears that are employed in our country. Almost all the types are represented in our fishing gear.

A casual stroll along the backwaters of Kerala and Cochin in particular will give the common sight of ladies crawling along the shallow waters with an earthenware pot floating. This represents the hand picking of prawns. Some times they even use 2 sticks by which they encounter the fish keeping it to form an angle at the bottom. So also at the rocky area and jetty sites with chisel and knives people collect molluscs. Diving for molluscs is also a common practice.

Stupefying methods are common among the tribals especially along the Nicobar coast where they use some herbs for stupefying fishes. This type of fishing is also reported from the tribals of Assam and the like.

Line fishing is a common practice throughout ad is represented by all types. All the methods are in vogue both in the inland and marine sectors. Ex: Troll lines for seer, hand lines for kalava etc.

Traps: Some of the marine types are lobster traps, kalava traps. etc. artificial reef for flying fish. Inland traps include traps for prawns, fish barrier, buoyed traps, raft traps, verandah nets etc. Traps for jumping fish is represented by changadam or changala pachil for prawns.

Bag nets are common both in inland and marine waters. To cite a few examples, - stake nets for prawns, dol net for Bombay duck, push nets, stow nets etc.

Dragged gear form the main gear for prawns

Trawls used by mechanised fishing vessel for both bottom and off bottom fishes and prawns are the main examples.

..4/-..

Seine nets are one of the main indigenous gear. To cite a few examples are Rampani net - shore seine - for mackerel and sardines used along the Goa and Mangalore coast, Thangu vala, Kamba vala, koru vala,odam vala of Kerala coast.

Encircling gill nets, and purse seines by mechanised vessels come under surrounding nets.

Dip nets: Examples of dip nets are given by Chinese dip nets.

Falling nets: Cast nets both inland and marine with andwithout pouches, cover pots (ottal).

Gill net is the common gear for inland and marine waters comprising all types. Simple set and drift gill nets for marine fishes like sardines , mackerels, seer, pomfret, hilsa etc. and simple and tangle nets for inland waters for fishes like carps and cat fishes, framenets and trammel nets.

Materials used for fish gear:

So far we have dealt with the gear types employed for fish capture and without giving a few words about the materials used for this, aspects will remain incomplete. In general fishing gear materials can be divided into two viz. natural and synthetics. Natural fibres constitute fibres like cotton, jute, flax, hemp, sisal, manila and coir used for twines and ropes in general; bamboo areca nut and palmyra etc. for barrier nets and traps etc. in particular. Metal rods wires are also used for traps and other accessories.

Synthetics are now slowly replacing natural fibres, the commonest being Polyamide, polyester, polyethylene, polypropylene, polyvinyl alcohol.

Examples of polyamide are -	nylon, Amilan, Anzalon
Polyester -	terylene, dacron
polyvinyl alcohol	Kuralon, Vinylon
Polyethylene	Polyethylene, Courlene
Polypropylene	Polypropylene, Ulstron.

Accessories: Floats & Sinkers cojointly keep the net in position, when the former lift the net, the latter keep it down. Material used for floats may be the age old examples of wood, empty tins, corks etc. or the sophisticated ones like, aluminium, plastic, thermocole and glass; likewise sinkers also can be either stone, granite pieces and metals or iron rings, lead sinkers of varying sizes and shapes, chains and depressors.

Kr/-

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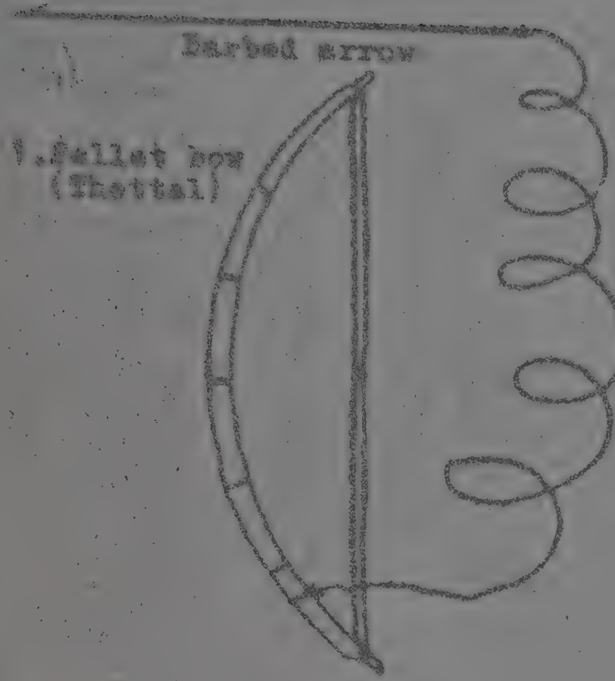
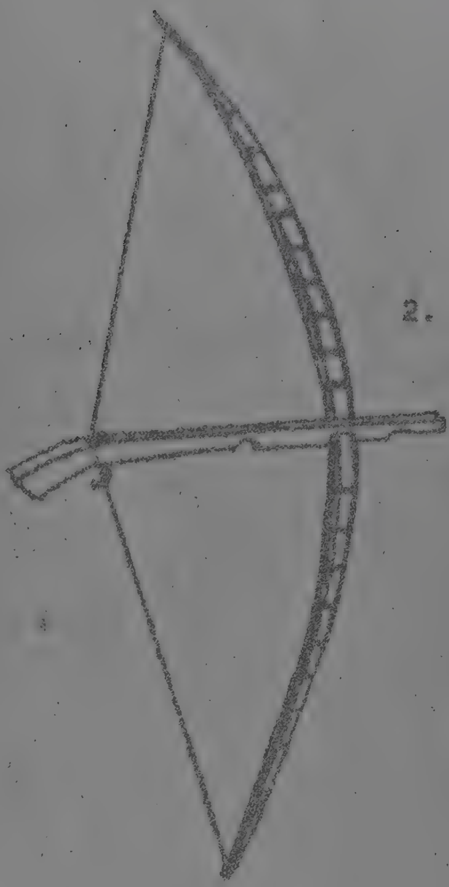
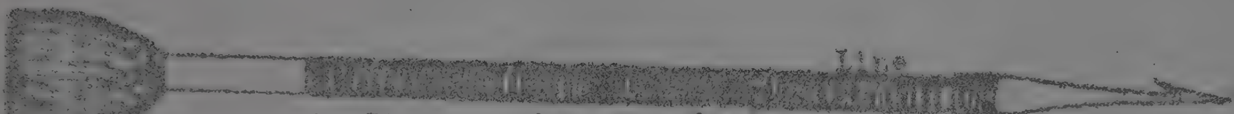

Barbed arrow

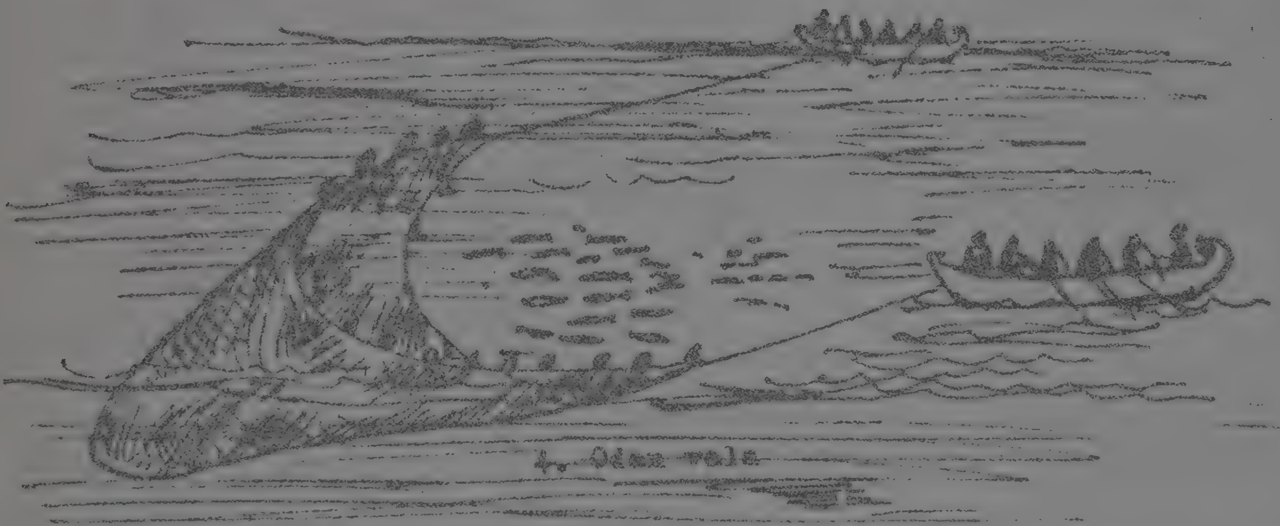
1.Pellet bow (Thettal)



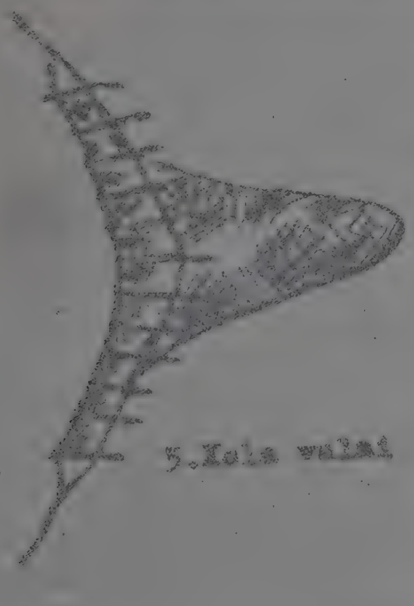
2. Crossbow


Line
Barbed steel head

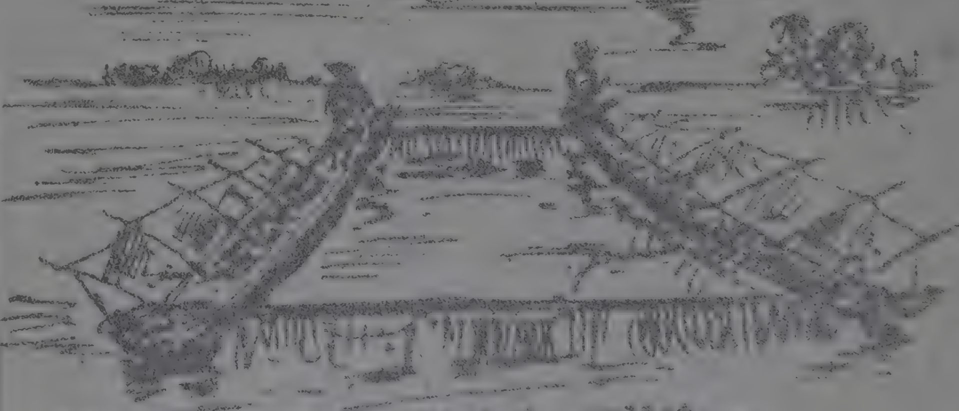
3. Blow gun harpoon dart



4. Odam vala

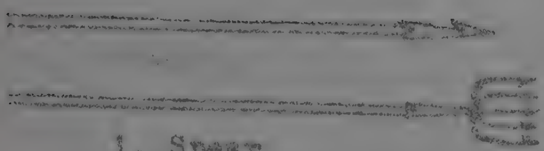


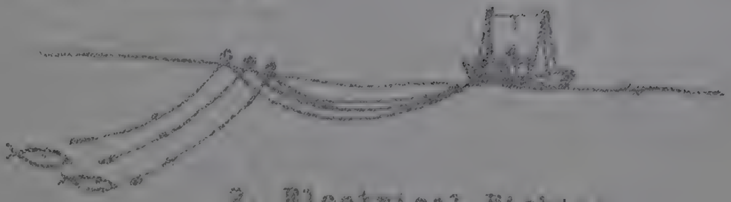
5.Kola valai

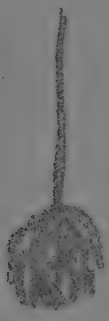


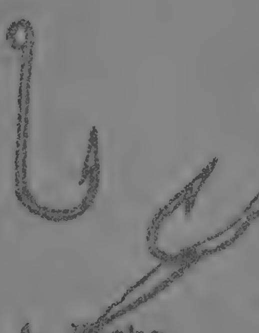
6. [illegible] for mullet

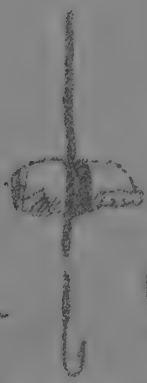
CLASSIFICATION OF FISHING GEAR.

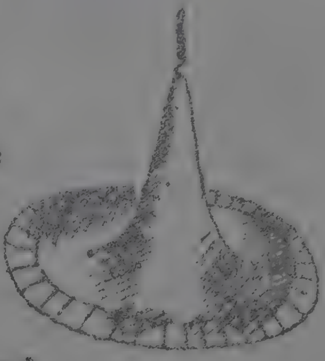

1. Spear

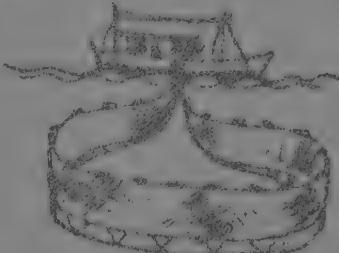

2. Electrical Fishing

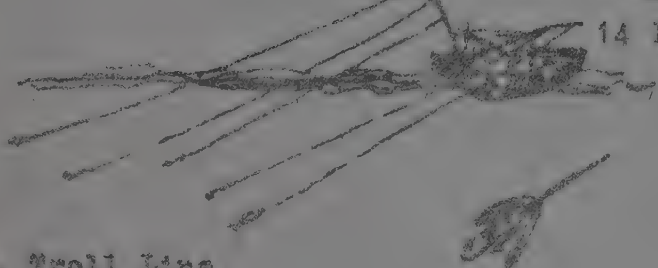

3. Without hook.

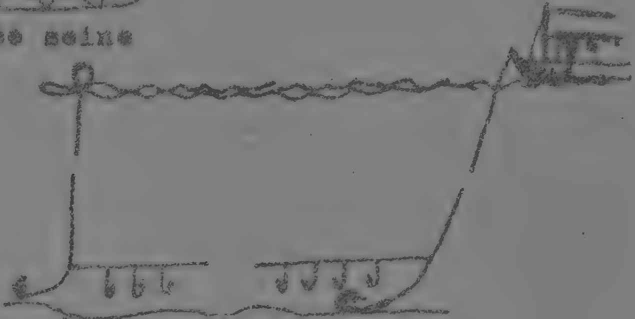

4. Hooks

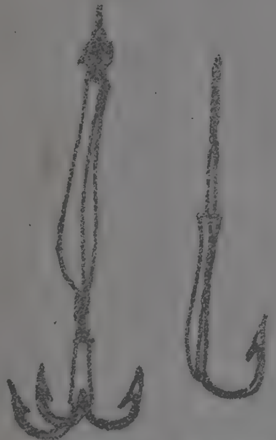

4 a. Hand line

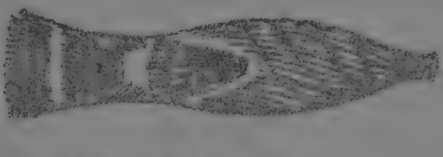

16 Cast net

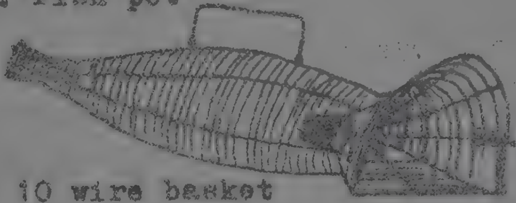

14 Purse seine

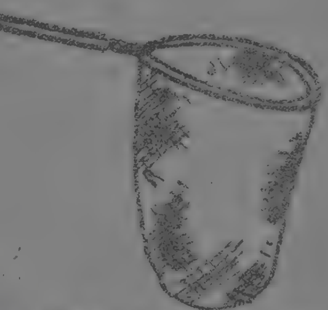

5. Troll Line

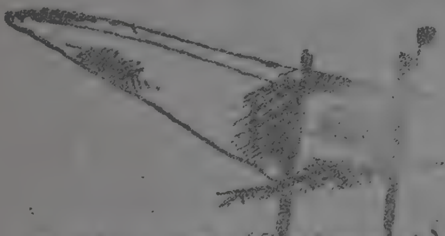

6. Long line

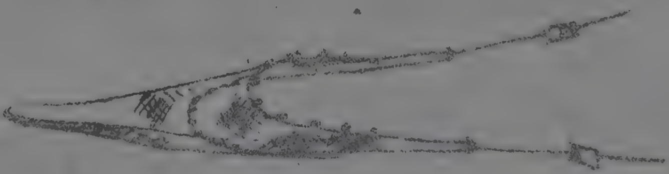

7. Lures (spoons)

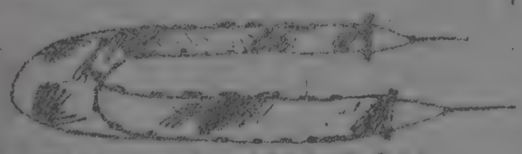

9. Fish pot

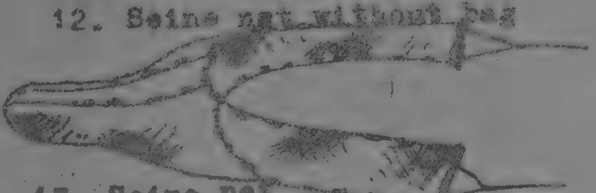

10 wire basket

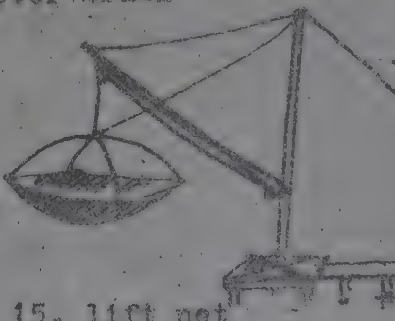

8 a. Landing net

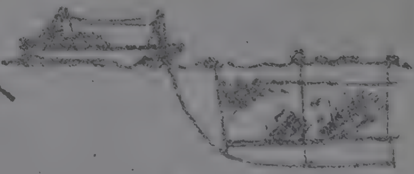

8.Stow net (Stake net)


11. Otter trawl

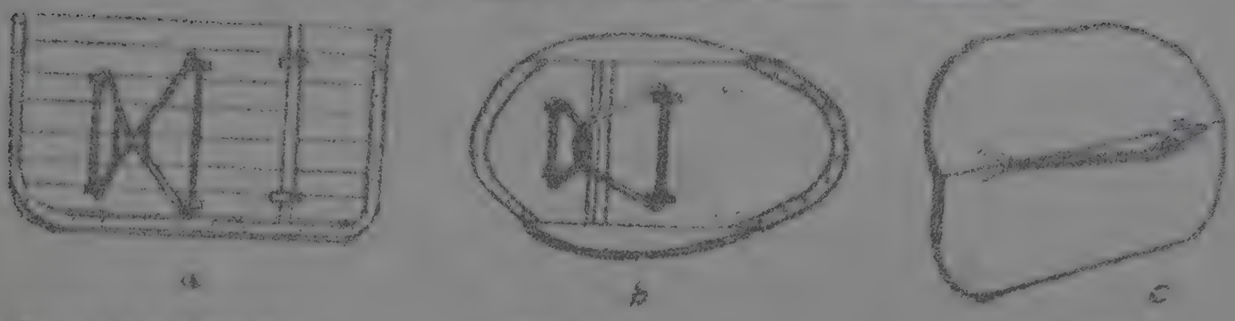

12. Seine net without bag


13. Seine net with bag


15. lift net

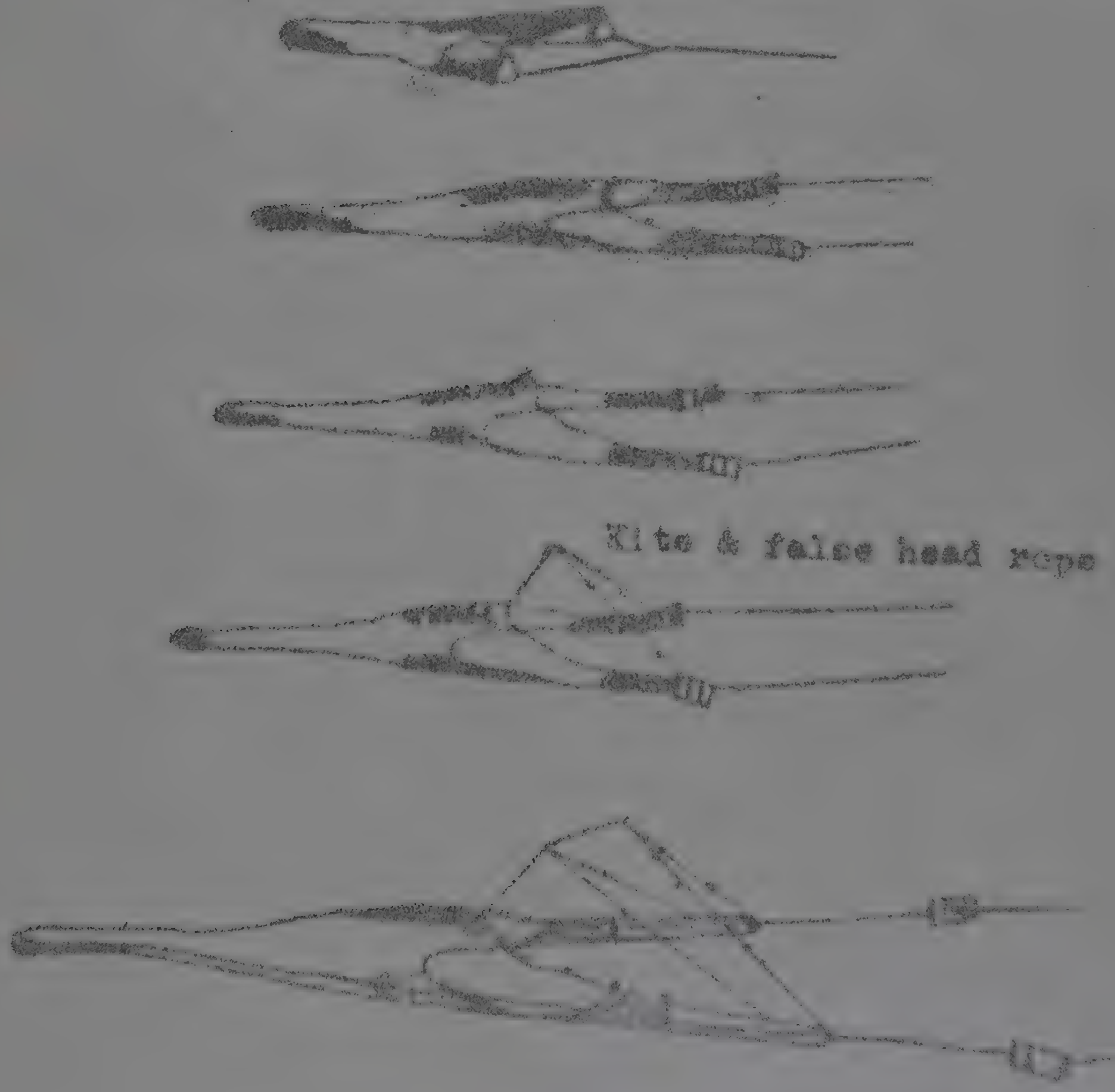

17 Gill net

1. Different types of otter boards.

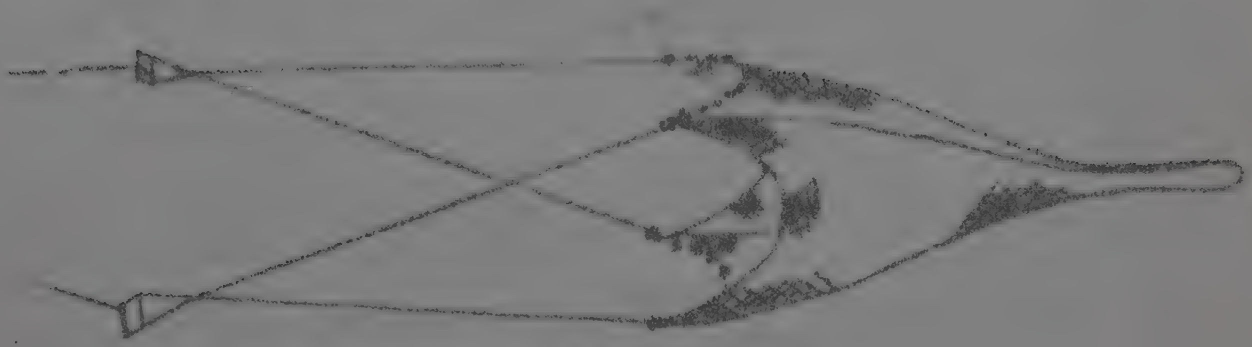


Conventional Oval V type

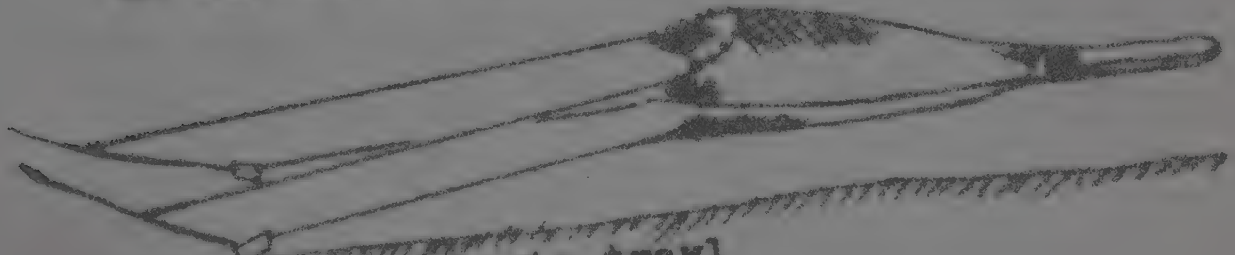
2. Development of bottom trawl.


Kite & false head rope

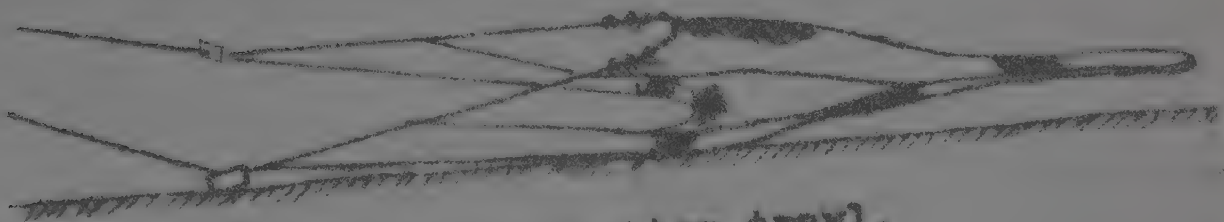
3. Types of trawls.



a. Mid-water trawl



b. Semi pelagic trawl



c. High opening bottom trawl.

BIOCHEMISTRY OF FISH IN RELATION TO FISH PROCESSING

BY

P.D. Antony,
C.I.F.T., Cochin-29

INTRODUCTION

The development of the fishery industry has been a succession of attempts to keep fish fresh between catch and consumption, given the choice people preferred, at all times, fresh fish to preserved fish, whatever may be the method of preservation. It is reflected in the gradual change from sun dried smoked, salted, salted and dried, iced (from natural sources only) frozen (using salt and ice) to live fish transportation in very early times; the latter system had the disadvantage of high mortality rate and consequently high cost. The whole trend changed with the advent of mechanical cooling systems, when frozen stored fish was a compromise between absolutely fresh fish and high cost.

The general preference for fresh fish is attributed partly to changes in physical appearance (texture, colour etc.) and largely to alterations in the nature and content of flavour /or odour bearing compounds taking place post mortem. An insight into the composition and an examination of the probable changes due to both inherent and external factors are essential to keep such changes to a minimum possible for maximum acceptability of the fishery products - the word fish as applied in this context includes all groups of animals living in water which are used as food, thus the crustace (prawns and crabs) mollusca (clams, mussels, oysters, cuttle fish, squid, octopus) are all grouped along with typical teleosts and elasmobranches.

Proximate Composition:

By proximate composition, though the etymology of the word is uncertain, is meant the content of major constituents and in the case of fish and related groups water, protein, lipid and ash. Large variations occur in proximate composition between (a) species to species (b) fish to fish in the same species (c) region to region in the same fish. Variations due to season and ground are also common.

Water

The water content of fishes may lie between 28% to 90%. In each species of fish the water content is highly variable due to growth, maturity, spawning, feeding and starvation. Water content as high as 96.18% is recorded in an extreme case of starvation in Hippoglossides platissoides.

Protein

The most important constituent from the nutritional point of view is protein. The content of protein may average about 19%, most fishes falling in the range 15-22 %, variations from 6 to 25% or even upto 28% are being reported; variations in protein content can occur due to spawning, starvation etc. compared to typical fishes, shell fishes fall in a lower category as far as protein content is concerned, with rare exceptions such as the Japanese ear shell with a protein content of 24.7%. Generally shell fishes may contain 8 to 15% of protein.

Lipid

The lipid content of fishes may vary from 0.2 to 64%, values as high as 67% is reported in the musculature of Salvenilus namayeush Siscowet. The lipid content in the case of fatty fishes may undergo wide fluctuations according to growth, maturity, feeding, spawning etc. Further there is a rise in fat content towards the tail region and from interior towards exterior in the musculature. There is always a higher percentage of fat in the ventral side than the dorsal side. The storage of fat in this manner has as the added advantage of reducing the 'drag' during swimming. During starvation or spawning fat is easily deplated from the musculature or liver as the case may be. As far as the nutritional value of fish is considered, fish with higher fat content will have high calorific value; however fat content is subjected to wide variations, and as no such wide fluctuations do occur in the case of proteins, lean fishes (including shell fishes) will have highly consistent nutritional value than fatty fishes, and generally most of the fishes fall in the category of low fat high protein group.

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Ash

The ash content of fishes lies between 0.4 to 2% and an inverse relationship has been noted with water content, especially when the latter rises during depletion (or starvation). The scale may contain 30 to 36% ash on a dry weight basis.

INTERRELATIONSHIP OF CONSTITUENTS

Fishes which store fat in the musculature shows an inverse relationship between lipid and water i.e. when lipid content rises water content falls, however keeping an average value of lipid + water=80% though a slight higher total percentage is often observed when the lipid registers higher percentage.

In the case of fishes, especially lean fiehes, a decrease in protein content is often associated with an increase in water content, though not as clearly marked as that of water-lipid relationship.

A rise in lipid content at times is associated with a fall in protein content, the relationship being clearer at higher percentage of lipid.

The ash content shows in general a slight fall with rise in water content such as during starvation or depletion.

COMPOSITION OF FISH MUSCLE PROTEINS AND THEIR SIGNIFICANCE.

1) Sarcoplasmic proteins:

This may constitute about 20 - 22% of the total protein of fish muscle and are characterised by their high solubility in water or low ionic strength salt solutions. This group comprises most of the fish muscle enzymes, which play major role in autolysis.

2) Myofibrillar proteins:

They are characterised by their solubility in high ionic strength salt solutions and comprise about 67 to 75% of the total protein in fish muscle and are directly involved in muscular contraction and rigor-, mortis.

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3. Stoma proteins

They are salt insoluble and are mainly the connective tissue, forming 3 to 6% in teleosts 6 to 12% in elasmobranches. The low percentage of connective tissue accounts for the highly soft nature of fish muscle when compared to other animal meat.

Fish lipid composition and significance

Fish lipids are of very special nature as there is a preponderance of poly unsaturated long chain fatty acids with 4 to 6 double bounds, which is very rare in the case of other animal lipids. These acids have the property of bringing down serum cholesterol levels and hence are of pharmacological importance. However because of the high unsaturation they undergo rapid oxidation and consequently oxidative rancidity, the latter mainly due to the break down products of the hydroperoxides of these acids, and some of the compounds formed may impart rancid taste or smell even in pph levels. Further the hydroperoxides of fatty acids are toxic as evidenced by feeding trials on rats. An important constituent of fish oils especially certain liver oils (such as shark liver oil and cod liver oil) is Vit. A and is used against Vit.A deficiency diseases. In addition to the fat soluble Vitamines especially A, D & E liver oils of certain elasmobranch fishes contain hydrocarbons such as squalene in very high proportions and pristane,Zamene etc. in traces.

The Ash

In addition to minerals such as Ca,Na & K which normally constitute the major constituent of ash, it may contain Cu, Fe, Mg etc. as minor constituents. Certain elements such as lead, Cadmium, mercury, arsenic, selenium etc. are found to be toxic. Filter feeders are found to concentrate these elements in them from the environmental waters. One of the most important element in this category is mercury which is found to be comparatively high in certain sharks, tuna, blue marlyn etc. - cases as high as 29.55 ppm is reported in the case of a 100 kg. blue marlyn; the concentration of mercury is found to be high in these fishes, and bigger the fish more the probability and higher the content in these fishes. Zinc is not considered as a toxic element, but if present in very high concentration may be toxic as is encountered with certain clams when taken in large quantities.

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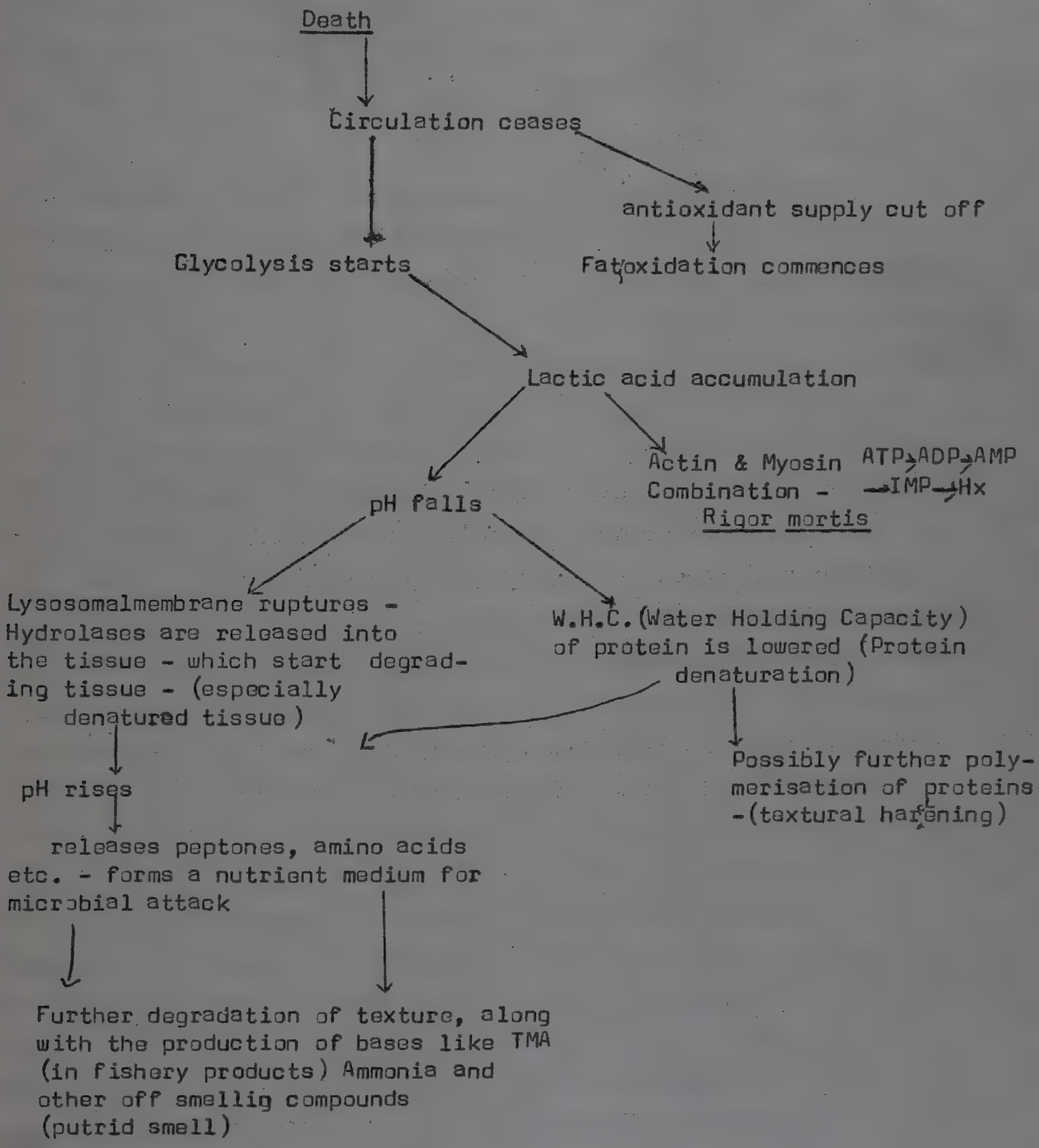
POST MORTEM CHANGES



Death

Circulation ceases

antioxidant supply cut off

Fat oxidation commences

Glycolysis starts

Lactic acid accumulation

Actin & Myosin Combination - Rigor mortis

ATP → ADP → AMP → IMP → Hx

pH falls

Lysosomalmembrane ruptures - Hydrolases are released into the tissue - which start degrading tissue - (especially denatured tissue)

W.H.C. (Water Holding Capacity) of protein is lowered (Protein denaturation)

Possibly further polymerisation of proteins -(textural hardening)

pH rises

releases peptones, amino acids etc. - forms a nutrient medium for microbial attack

Further degradation of texture, along with the production of bases like TMA (in fishery products) Ammonia and other off smelling compounds (putrid smell)

1) Fish tissue is supplied with antioxidants such as a- tocopherol (Vit.E) through the circulatory system. But once the circulatory system fails the lipid in the tissue undergoes rapid oxidation by atmospheric oxygen, which is further catalysed by 'heme' present in tissue - consequently onset of oxidative rancidity.

2) as aerobic oxidation is arrested anaerobic oxidation of glucose (glycolysis) to lactic adic is the predominating reaction, and accumulation of lactic acid brings down the pH, resulting in the loss of waterholding capacity of proteins (W.H.C.) - i.e. protein is progressively denatured - which can further undergo aggregation or polymerisation. The denatured proteins are ideal substrates for proteolytic enzymes. Further the myofibrillar proteins (the constituent of muscle fibres) actin and myosin undergo acto-myosin combination accompanied by adenosine triphosphate hydrolysis(ATP) to ADP - the former reaction results in muscle fibre shrinkage -(Rigor mortis sets in) the latter compound undergoes a series of step wise reactions with the production AMP ---- IMP ---- Hx. (IMP is a flavouring agent, Hx - Hypoxanthe is bitter or imparts off flavour). Further lowering of pH reptures the lysosomal membrane releasing its contents of hydrolases, such as proteinases, nucleotidases, lipases etc. and the tissue constituents such as proteins, lipids and nucleic acids are rapidly degraded. The degradation of proteins has the added effect of raising the total waterholding capacity and pH. Through the concerted attack by these enzymes, the fish tissue is converted to an ideal nutrient medium for microbial proliferation as it is provided with amino acids and peptones, nucleotides all the essential vitamines and minerals. This marks the onset of rapid microbial spoilage, the latter are capable of producing extracellular enzymes to degrade the tissue further and concommitant rise of spoilage indices such as TMA, TVB etc. The lipases cause fast hydrolytic rancidity especially in the case of fatty fishes and fishes with high phospholipid content.

INDICES OF QUALITY

1. TVN(TVB) (Total Volatile Nitrogen/Bases)

As fish undergoes spoilage the content of Total Volatile Nitrogen/ Bases increases - which more or less directly correlates with spoilage

2. TMA (Trimethyl amine)

Trimethyl amine oxide (TMAO) present in fish especially marine fishes are reduced to TMA and an estimation of which serves as a useful index for bacterial spoilage; TMA development in fish under asceptic condition is negligible.

3. a- Amino Nitrogen

During spoilage tissue proteins are degraded to simple peptides Aminoacids etc., thereby increasing the content of free a- Amino groups mostly TCA soluble, the content of which serves as an index of the extent of spoilage.

4. Hypoxanthine

The enzymes present in fish tissue decomposes ATP through a series of steps and finally to hypoxanthine and an estimation of which is used as an index of quality of fishery products.

5. Salt solubility

In processing methods which causes protein denaturation such as cooking, freezing, frozen storage etc. the extent of protein denaturation occurring can be evaluated by salt solubility measurements or by cell fragility measurements when the content of salt soluble proteins decrease due to denaturation as compared to fresh fish, measurement of salt solubility will be a useful index of protein denaturation.

6. Protein denaturation can also be evaluated by the cell fragility test when the soluble proteins from a sample tissue (sample size can be very small, as little as 200 mg.) is rendered opaque by TCA & formaldehyde and measured spectrophotometrically. The method is simple, sample size very small (i.e. sampling loss negligible) and large number of samples can be handled easily. The O.D. of sample will decrease progressively with denaturation.

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7. Cell damage due to ice crystal formation during freezing and frozen storage can be evaluated by measuring the content of Aspartyl amino transferase (AAT) after electrophoresis of thaw drip samples of frozen material, as the content of this enzyme in the thaw drip increases (as the AAT is released due to membrane damage) increases progressively with frozen storage.

8. As fish spoils the electrical resistance of the tissue falls progressively. The extent of autolytic spoilage can be evaluated using the system measuring electrical resistance. Capacitance also varies with spoilage hence capacitance measurement can also be used for measuring freshness of fish.

Free Fatty Acid, Volatile Acid Number, Peroxide Value, Thiobarbituric Acid Value are indices of hydrolytic and oxidative rancidity of oils

1. Acid Value & F.F.A. (Free fatty acid) of fat Acid value is the number of m g of KOH required to neutralise the free acid in 1 g. of sample

$$\text{A.V.} \quad \text{Vol. of } \frac{0.1 \text{ N KOH} \times 5.61}{\text{sample weight}}$$

Procedure

About 1 to 10 g. fat mixed with 50 ml 1:1 ethyl ether : Ethyl alcohol (neutralised with 0.1 N alkali) mixture and titrated with standard 0.1 N Sod. hydroxide /Pot. hydroxide (with constant shaking using phenolphthalien as indicator to a persistant (15 sec.) pink colour.

Free fatty acids are usually expressed as oleic acid (m. wt. 282)

$$\text{F.F.A.} = \text{ml of } \frac{0.1 \text{ N alkali} \times 0.0282}{\text{wt. of fat taken}}$$

$$\text{Acid Value} = 2 \times \text{F.F.A.}$$

In the case of fish muscle, fat is extracted by petroleum ether extraction of dried muscle or / Chloroform extraction after Sod. sulphate (anhydrous) drying of wet tissue

V.A.N. (Volatile Acid Number)

50 g of minced meat is mixed with 150 ml distilled water and finely dispersed (in a 500 ml flask), add 25 ml 1N sulphuric acid, thoroughly mix and add about 40 ml of 20% phosphotungstic acid (to precipitate proteins) and make

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the total weight of sample and reagents 300 gm by adding distilled water and filter through fluted filter paper after thorough shaking for about 1 min. Steam distill 150 ml of the filtrate, collect 200 ml of distillate and titrate with N/100 NaOH - The Volume of N/100 NAOH for 100 g. of tissue is designated as Volatile Acid Number.

$$\text{VAN} = \text{VOL of N/100 NaOH} \times \frac{300}{150} \times \frac{100}{50}$$

$$= \text{VOL of N/100 NaOH} \times 4$$

3. P.V. (Peroxide Value)

A suitable sample to yield about 2.5 g. fat is dried with sodium sulphate (anhydrous) and extracted with distilled chloroform, a suitable volume of aliquot (15 ml) is mixed with 3 ml aldehyde free glacial acetic acid 1 ml of saturated potassium iodide solution is added and kept in the dark for 10 mts. 70 ml. water and 1 ml. 1% starch solution is added and titrated with N/500 thiosulphate solution.

PV = ml of N/500 thio/ g. of fat (the fat content is determined by evaporating a known volume of chloroform extract)

$$\text{PV} = \frac{\text{Ml of thio required}}{\text{wt. of fat in the Chloroform extract}}$$

4. T.B.A (Thiobarbituric Acid Value)

Principle: oxidized fat reacts with thiobarbituric acid to produce a red pigment, the reactive material is supposed to be malonaldehyde mainly produced from methylene separated dienoic (or polyenoic) acids .

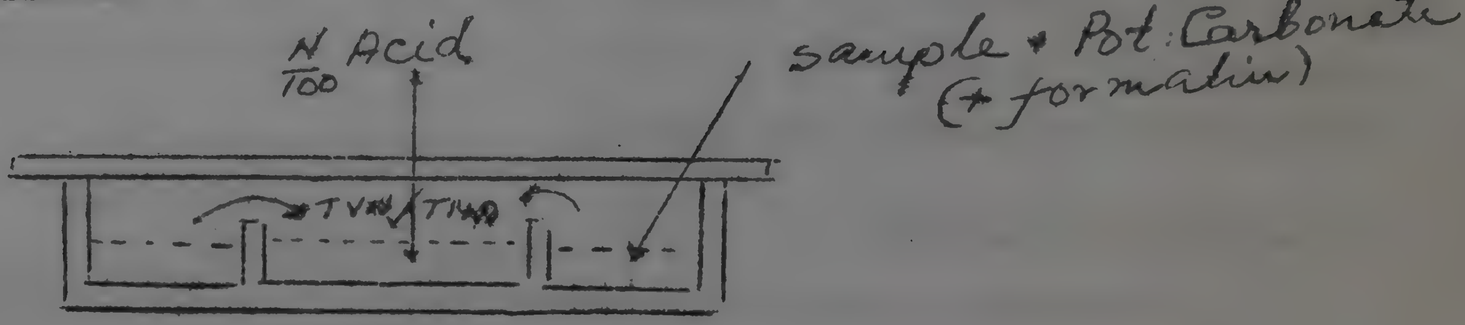
50 g. fatty food mixed with 50 ml. distilled water for 2 minutes and wash down into a distillation flask with 47.5 ml distilled water, add 2.5 ml. 4 N HCl (pH 1.5 final) and heat the flask (after adding a few glass beads to prevent bumping) and collect 50 ml distillate in 10 minutes from the commencement of boiling.

Pipette 5.0 ml distillate into a glass stoppered tube add 5 ml. TBA reagent (0.2883 g TBA/100 ml 90% glacial acetic acid) stopper and heat in boiling water bath for 35 minutes cool and measure the O.D. at 538 nm in 1 cm cells against Blank, prepared using 5 ml water instead of distillate. Standard curve is prepared using 1-1, 3-3 tetra ethoxy propane instead of sample.

TBA = Optical density x 7.8 mg malonaldehyde/100 g meat

..10/-..

1. TVB OR TVN (Total volatile Bases or Total Volatile Nitrogen)



Preparation of extract

20 g muscle ground well with 20 ml 20% TCA and filter by decantation triturate the residue with 1% TCA collect the washings and the total extract made upto 250 ml. This extract can be used for the estimation of TMA, TVN(TVB) and a- Amino nitrogen.

1 ml of N/100 sulphuric acid or Hydrochloric acid is taken into centre well of waxed conway micro diffusion apparatus, 1ml of the prepared extract and 1ml of saturated potassium carbonate are added in the outer chamber, the apparatus closed immediately and kept over night or 1 hour at 38°C.

The acid in the centre well is titrated with N/100 NaOH using Tashiro's indicator = (B). A blank is also run using 1 ml. distilled water instead of TCA extract = (A); Value (A-B) is = ml of N/100 Acid used up by volatile bases.

(1 ml of N/100 acid = 0.14 mg N)

T V B N :(A - B) x 0.14 in mg.

$$\text{T V B N mg\%} = \frac{(A - B) \times 0.14 \times \text{volume of extract} \times 100}{\text{Volume of sample taken (1 ml)} \times \text{wt. of sample}}$$

2. TMA (Trimethyl Amine)

The above procedure is used for TMAN - but in the outer chamber 0.2 to 0.5 ml formalin is also added to fix bases other than tertiary amines. Calculations are also similar.

3. a- Amino Nitrogen

To 5 ml of above extract neutralised with 1 M NaOH , using thymolphthaline as indicator. add 30 ml of copper phosphate suspension (made by mixing

(1) 27.3 g $CuCl_2$ in 1 litre

(2) 64.5 g Na_2 HPO_4 in 500 ml distilled water and 7.2 g NaOH make upto 1 litre

(3) 57.2 g Sod. Borate in 1500 ml. distilled water add 100 ml 0.1 N HCl make upto 2 litres

in the ratio 1:2:2 respectively) make upto 50 ml with distilled water and filter. To 10 ml of filtrate add 0.5 ml glacial acetic acid and approximately 1 g of KI and titrate the liberated iodine with 0.01 N Thiosulphate using starch as indicator. 1 ml of 0.01 N Thio = 0.28 mg of a- amino Nitrogen. The results are expressed as mg of a- Amino Nitrogen/100 g of tissue

4. a) Hypoxanthine

25 g tissue homogenised with 50 ml 0.6 N Perchloric acid at 0° and filtered. A suitable volume of extract (50 ml) is neutralised with 30% KOH (to pH 6.5 to 7.0) at 0°C and the volume adjusted to 75 ml. $KClO_4$ precipitates out and is removed by centrifugation.

About 0.5 ml of above extract is mixed with 2 ml distilled water followed by 2 ml 0.25 M phosphate buffer pH 7.6 and 0.5 ml Xanthine oxidase (containing 0.032 I.U of xanthine oxidase activity) and incubated at 37° for 30 minutes and the optical density is measured at 290 nm. Blanks are also run with the extract but without the addition of xanthine oxidase. Standard curve is prepared using hypoxanthine as standard. Hypoxanthine can also be determined by silver salt method.

5. Cell Fragility Test

200 mg tissue blended in Torry Brown homogeniser at 8750 rpm with 20 ml 2% TCA containing 1.2% formaldehyde for 30 seconds. The optical density is measured at 430 nm. Higher the optical density lesser protein denaturation (i.e. more proteins are soluble from less denatured tissues) Calibration for each species of fish is preferred.

6. Salt Solubility 10 g tissue is blended with 100 ml 5% NaCl containing 0.02 M $NaHCO_3$ for 1 minute at 0-4° and is centrifuged at 2000 rpm. Nitrogen content of the centrifugate is determined by Kjeldahl method - salt soluble protein nitrogen is used as a measure of protein denaturation, lesser the value more is the extent of protein denaturation. Salt soluble Nitrogen is expressed as percentage of total nitrogen.

FUNDAMENTALS OF BACTERIOLOGY OF FISH & SHELL FISH

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INTRODUCTION

Bacteria are single-called micro-organisms widely distributed in nature. They are found in all environmental conditions. They are present in the intestinal tracts and body surface of animals, soil, and the natural waters like ponds, lakes, rivers and the sea. There are both useful and harmful or disease-producing bacteria. Many bring about such useful changes as the decomposition of dead tissues of plants and animals while some of the disease-causing types of pathogenic bacteria cause various types of illness in man, animals and plants. Almost all the animal and vegetable foods are decomposed by bacteria if the foods are not preserved properly.

MORPHOLOGY

Bacteria are single-celled organisms seen only through microscope. They occur in any of the three fundamental shapes.

SHAPE

1. Spherical
2. Rods
3. Spiral or curved rod.

SIZE

The size ranges from 0.5 μ to 100 μ in length, the common range is 1 to 3 μ for the rod form and 0.5 μ for the diameter of the spherical bacteria (one μ = Micron = $\frac{1}{1000}$ th of a millimeter)

REPRODUCTION

Unddr favourable conditions a single cell of bacterium multiplies by breaking apart into two. This method of multiplication is called binary fission.

FLAGELLA

Some bacteria show hair-like appendages on their body. There are called flagella (flagellum-singular). They usually confer 'motility' (i.e. capacity to move) in bacteria especially in a liquid medium. Usually rod-shaped bacteria possess flagella. The number of flagella varies from one to many.

SPORE-FORMATION

Some bacteria form spores to resist unfavourable conditions like heat, cold, dryness etc. These are produced from the normal vegetative cells which undergo modification to form spores. Usually some of the rod shaped bacteria produce such spores. When favourable conditions return the spore 'germinate' to form the original vegetative cells.

GRAM-STAIN

One of the methods of classifying bacteria is to find out whether they are gram positive or gram-negative. If after gram-staining, bacteria take up a violet colour, the organisms are said to be gram-positive and if red, the organisms are said to be gram-negative.

METHOD OF GRAM-STAINING

A thin bacterial film on a glass slide is covered with a solution of Crystal violet for a fixed time (1 mt). The stain is washed off with water. Then a dilute solution of iodine is added over the film and allowed to remain for the same period of time. After this, the slide is washed with rectified spirit until no more colour comes from the film. Finally a counter stain like Safranine (red) is poured over the film and allowed to remain for 1/2 mt. The slide is then washed with water and allowed to dry.

Some organisms retain the violet stain even after washing with alcohol so that the red counter stain is not taken up by the film. Such organisms appear violet under microscope and are termed gram-positive.

Others do not retain the primary stain (ie) Crystal violet during the washing of the film by rectified spirit. They take up the counter-stain (Saffranine) and appear red under microscope. They are gram-negative.

In addition to above, there are organisms which are weakly gram positive or gram variable.

CONDITIONS OF BACTERIAL GROWTH

Growth of bacteria is influenced by the environmental conditions and availability of nutrients. The environmental conditions include temperature, pH (Acidity or alkalinity of the substrate) and presence or absence of oxygen.

1. Effect of temperature

Bacterial growth is profoundly influenced by temperature. Each species of bacteria grows at temperatures within a certain range. On this basis, bacteria are divided into the following groups.

A. Psychrophiles as the name itself indicates are cold-loving bacteria. They are able to grow at low temperatures say between 0°C or slightly lower and 20°C with an optimum growth temperature at about 15°C. Same of them cause spoilage of food at low temperatures.

B. Mesophiles are those which grow best within a temperature range of approximately 20-45°C with an optimum of 30° - 37°C. The disease causing bacteria or pathogens come under this group. Majority of the bacteria belong to this group.

C. Thermophiles- are those which grow best at temperature between 45° - 65° or even upto 90°C. Their optimum temperature of growth is about 55°C. Some of the bacteria occurring in natural hot springs can thrive at a temperature of 85° - 90°C.

Type of bacteria	Range of growth temperature	Optimum growth temperature
Pychrophile	0-20°C	15°C
Mesophile	20-45°C	30-37°C
Thermophile	45-90°C	55°C

2. Effect of pH

pH is a measure of acidity or alkalinity of a medium and is expressed as a number. pH 7 indicates a neutral medium. Eg. water which is neither acidic or alkaline, whereas acids like hydrochloric acids sulphuric acid etc. in solution are strongly acidic and their pH is less than 7. Solution of alkalics like sodium hydroxide etc. show a pH range of 7.5 to 15. So for acidic range the pH values are below 7 and for alkaline ranges the pH values are above 7.

For growth of bacteria, the optimum pH of the growth medium is usually between 6.5 and 7.5. Only special types of bactdria and fungi require pH which is either in the acedic side or on the alkaline tide.

3) Gaseous requirements

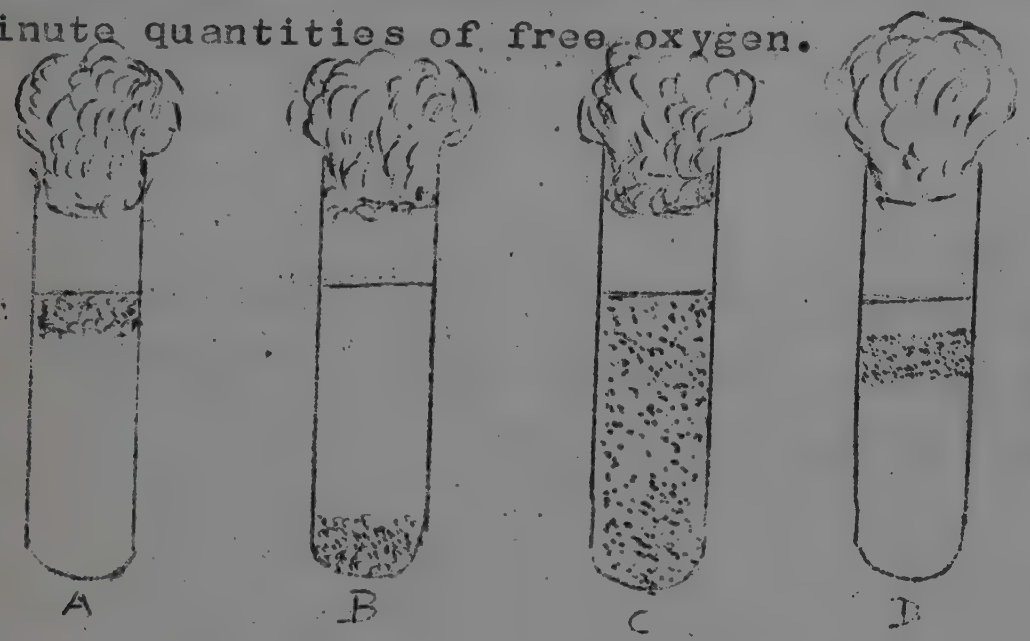
The principal gases that affect bacterial growth are oxygen and carbon dioxide. On the basis of oxygen requirements, bacteria are grouped as follows:

A. Aerobic bacteria or aerobes - grow in presence of free oxygen.

B. Anaerobic bacteria or anaerobes - grow only in the absence of free oxygen.

C. Facultative an-aerobes - grow both in the presence or absence of free oxygen.

D. Micro aerophilic bacteria - grow in the presence of minute quantities of free oxygen.



A. Aerobe C. Facultative anaerobe
B. Anaerobe D. Microaerophile.

4. Nutrition

All bacteria require proper nutrition for growth. On the basis of their nutritional requirements, bacteria can be grouped into autotrophs and heterotrophs. Autotrophs have simplest nutritional requirements. Heterotrophs require usually complex nutrients for proper growth. Many of the pathogenic and fish spoiling bacteria are heterotrophs.

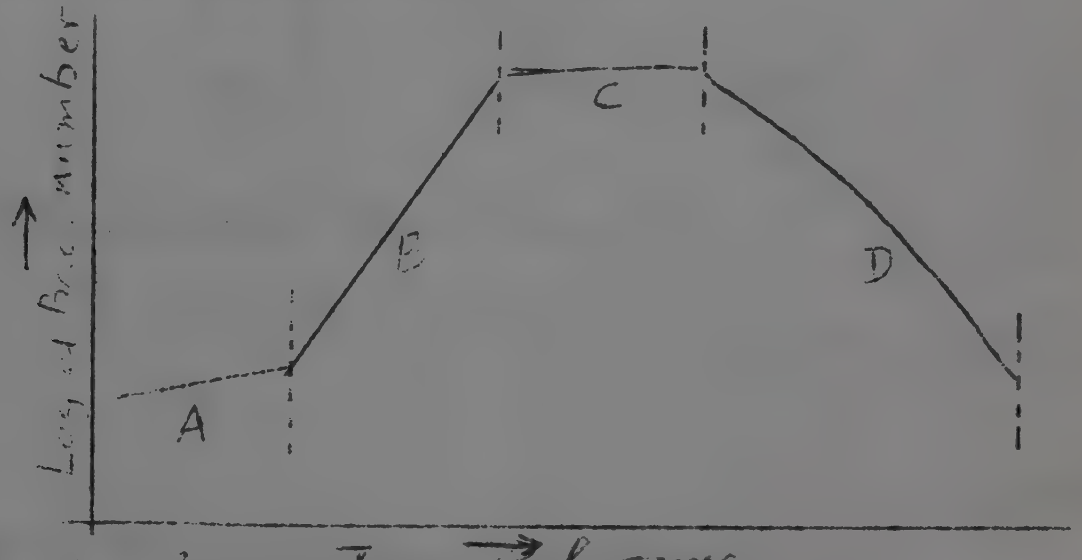
Reproduction and growth of bacteria

Bacteria, when introduced into a suitable medium or substrate under appropriate conditions, increase greatly in number within a short time. Some species increase to maximum population within 24 hrs. whereas others require a longer period.

Bacteria multiply by binary or transverse fission (ie) one cell dividing into two, two into four, four into eight and so on. So starting with a few cells, the number reaches to astromomical proportions in a short time provided the growth conditions are satisfactory.

Growth phases

If a few bacteria are introduced into a fresh medium and suitably incubated, the growth of bacteria follows the pattern shown below:



A. Lag phase
B. Logarithmic phase
C. Stationary phase
D. Death phase.

A. The Lag phase: Immediately after the inoculation, the bacteria are adjusting to the physical environment around them. The organisms are active metabolically, but cell division is not taking place and hence this stage is called lag phase or period.

B. The Lag arithmic phase or Exponential phase

During this period, the cells divide steadily at a constant rate. Growth is maximum during this phase.

C. The Stationary phase

At this phase, the number of cells remains constant; number of cells produced is equal to the number dying.

D. **The Death phase** : At this phasd more cells are dying than the number produced. This is caused by depletion of essential nutrients in the medium and/or accumulation of toxic products.

The above is the pattern of bacterial growth under ideal conditions, but in nature, this need not be followed every time because of possible variations in environmental conditions.

Bacteriology of fish

General: Fishes as caught from any waters cohtain microflora, the nature of which depends on the microbial types and contents of the waters from which the fishes are caught. Fishes are caught from the open sea, backwaters, fresh water lakes and rivers, each containing its own types of bacteria which influence the microbiological quality and spoilage of the fish caught from the respective waters.

Bacteriology of natural waters:

Sea: Sea water contains varied typed of microflora. These bacteria are not free-swimmers, but are usually found in association with planktons and other marine flora and fauna. Far out into the sea, the flora are more or less typically marine. But near shore and at harbour months, the waters contain varying proportion of terrestrial bacteria. One characteristics of marine bacteria is that they are able to tolerate a higher concentration of sodium chloride than the terrestrial bacteria.

Backwater:

These are generally areas of intermingling of fresh and saline waters. The salinity of these waters is not constant as in open sea, but fluctuates with season, tidal influx etc. These waters also contain varying proportion of fresh water bacteria as well as bacteria of marine origin.

3. Fresh water lakes and rivers

These also contain bacteria, their principal characteristics is their low tolerance to sodium chloride. But these bodies of water, especially if they happen to be near human habitation, are subjected to faecal contamination which introduce pathogenic bacteria into the waters. Consequently fishes caught from these waters are likely to be contaminated by these bacteria also.

Occurrence of bacteria or fish:

A freely swimming fish in the sea harbours bacteria mainly at three sites 1. the surface slime 2. the gills and 3. guts, especially in a feedy fish. The muscle or flesh or other internal organs like liver, heart etc. of a healthy fish are sterile.

As long the fish is alive, the activity of these bacteria is under check and they can not act on fish muscle. But once the fish is dead, these bacteria start attacking the flesh, thereby initiating the phenonmenon of microbial spoilage.

Bacterial load on fish:

This means the number of bacteria per gram of fish muscle or per unit area of the fish surface. For e.g., in ocean-fresh sardines, the figures are as follows:

On the skin & muscle - 10^3 to 10^5/g
At gills - 10^5 to 10^6/g
In guts - 10^5 - 10^8/g

In general the magnitude of bacterial load is guts > gills > skin and muscle.

Types of genera of bacteria on fish

One important characteristic of the microflora of ocean-fresh fish is that more than 90% or sometimes 100% of the microflora consists of gram-negative rods. Only a very low percentage of gram-positive organisms is present in ocean-fresh fish.

But once the fish is landed on the boat~~s~~-deck, or taken to wharfs, factories etc. the proportion of gram positive organisms increases depending on the extent of terrestrial contamination. A typical generic distribution of bacteria on skin and muscle and guts of fresh sardines is given below:

Bacterial genus	Percentage in skin & muscle	Percentage in Guts
Achromobacter	32	30
Vibrio	27	15
Pseudomonas	14	30
Flavobacterium & cytophaga	11	2
Corynebacterium	7	1
Micrococci	6	1
Bacillus spp.	1	0
Aeromonas	1	3
Photobacterium	1	18

In the case of prawns, the bacterial load is a little higher than in fish. They are also subceptible to to bacterial spoilage much faster than fishes.

Microbial spoilage of fish and methods of prevention

One of the striking similarities between man and the microbes is that their food requirements are much the same. The most nourishing of human foods are almost always ideal foods for bacteria. That is the reason why milk, egg, meat and fish spoil so rapidly once they have been contaminated by bacteria in sufficient numbers. What we often call spoilage is, in essence, nothing more than a partial digestion of food by myriads of these little organisms. During this digestion varying amounts of volatile and non-volatile compounds are liberated from the foods. More often these possess bad odours which indicate that the spoiling phenomenon has set in. Volatile amines and organo-sulphurous compounds are examples of such compounds.

Methods of preservation

ICING

The simplest method of preventing spoilage of fish and prawns is icing. By mixing with sufficient quantity of ice, the temperature of the fish is brought down. Once the temperature is brought down, the activity of these bacteria is reduced and the onset of spoilage delayed. Normally under tropical conditions fish kept at ordinary temperature will start spoil after 6 to 7hrs and become unfit for human consumption. But iced properly, fish can be kept in prime condition for a few days say 4 to 6 days. After this period, in spite of the fish being kept in ice, the spoilage starts because of the increase in the number and activities of cold-loving bacteria (psychrophiles) which thrive at low temperatures. This method of keeping the fish fresh is mainly intended for short-term storage of fresh fish not exceeding 5 to 6 days.

FREEZING

For longer storage of fresh fish, another method is freezing wherein the temperature of the fish is brought down to sub-zero temperatures of -20°C to -40°C in freezing machines and then storing the frozen fish at sub-zero temperatures (at -20°C). This method reduces the bacterial content of the fish by 60 to 90%. Freezing causes death to some of the bacteria or considerable reduction in their viability. At sub-zero temperatures, the activities of the surviving bacteria comes to a stand-still and hence the fish keeps well for longer periods say a few months under frozen conditions.

HEATING

By the application of heat also, the bacterial content in a food can be reduced. This is achieved in canning of fish and fishery products. The aim here is to achieve more or less complete destruction of bacteria by enclosing the fish or fishery product in a metal can of suitable size alongwith a suspending fluid, usually brine or oil and then heating the cans under stipulated tdmperature in special vessels. The processed product is almost free from bacteria and hence keeps well for months at a stretch.

Pasteurisation is another process which is effected either by heat or high energy irradiation. Here also a partial destruction of bacteria in foods is effected. This reduction in number of bacteria slows down the development of spoilage flora and delays spoilage if not prevents it altogether.

USE OF CHEMICALS:

Other well-known methods to control the bacterial proliferation in fishery products is the use of certain chemicals like sodium chloride coupled with dehydration. This method is employed in the preparation of cured fishery products. The high salt content in the product keeps down the bacterial multiplication and the product is thus given a considerably longer shelf-life.

In general, partial inhibition processes are most effective when applied very soon after the death of the fish. Once the spoilage flora has entered into a stage of vigorous growth, such processes are of little value.

Microbial hazards in fish and fishery products:

The natural microbial flora found on fish or shell fish as caught from natural waters away from land masses consists of bacteria which are harmless to human belongs.

But subsequent handling of fish after catch is likely to contaminate it with varying kinds of bacteria of terrestrial origin including those which are pathogenic to humans. The chances of contamination with such harmful bacteria are high unless a high degree of sanitation is maintained from the moment of catch till it reaches the consumer. The pathogenic bacteria which are likely to contaminate the fish are Coliforms, *Escherichia coli*, faecal streptococci, Salmonella, Staphylococci, Clostridia etc. All these groups of bacteria are of human origin except perhaps the Clostridia whose natural habitat is soil. The occurrence of the first three groups of bacteria on fish or ~~fix~~ processed fishery products indicates faecal contamination and is a pointer for the likely presence of Salmonella which is a greater pathogen and hence must be totally absent from any fishery product. While the occurrence of a certain minimum number of Coliforms, *Escherichia coli* or Streptococci and Staphylococci is allowed in fish and fishery products, presence of even a single cell of Salmonella makes the fish unfit for human consumption. Salmonella are known to produce enteric fevers and diarrhea when they infect the human system through food. These organisms generally do not grow at 0°C and at refrigeration temperatures but above such temperatures they are likely to grow in foods under favourable conditions and infection ensures by consuming such contaminated foods. The chance occurrence of Salmonella organisms in fish meal is likely to cause Salmonella infection in poultry when infected fish meal is fed to chickens. Fortunately Salmonella are heat-sensitive and the heating of fish meal to about 60°C under standard conditions eliminate this hazard and makes it safe for poultry feeding.

While Salmonella causes infective type of food poisoning, the case of Clostridia is different. They produce a powerful toxin which is lethal for human beings. These organisms grow in environments where oxygen is absent or present only in trace amounts. Canned prawns and fish are prone to develop this type of poisoning if the processing parameters happen to fall below standards resulting in under-sterilization of cans. It has been observed that meat foods including fish stored at room temperature or under slight refrigeration may also become dangerous rapidly due to growth of this organisms but will remain safe for a considerable length of time at less than 10°C. Clostridium botulinum may sometimes develop and produce toxin in frozen foods which have been allowed to thaw and then stored at temperatures 10°C or higher. However, frozen foods, if properly handled and kept frozen until use, are probably as safe as fresh foods.

Food poisoning caused by Staphylococcus ~~in~~ is probably milder in effect. These organisms are carried in throats of human beings and found in great numbers in the nasal discharge following common cold and in wounds. Obviously workers with nasal infection or recurrent cold should be excluded from handling of fishery products in processing factories. The organisms do not produce toxin at temperatures of 4 to 6°C of storage. Above this temperature, toxin is produced under favourable conditions which is likely to cause food poisoning.

In general, a high degree of sanitation is to be maintained, from the moment the fish is caught till it reaches the consumers' table. The use of good quality ice for preserving raw fish, the periodical cleaning of boat decks, fish boxes, fish holds, efficient cleaning of table taps, utensils in processing factories with good detergent and subsequent washing with chlorinated water and above all maintenance of good personal hygiene among factory personnel ~~hygiene among factory personnel~~ will go a long way in the improvement of the bacteriological quality of sea foods and make them more wholesome and safe for human consumption.

Handling of Fish on-board Fishing Vessels

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INTRODUCTION

The quality of fish reaching the consumer or the processing factories will greatly depend on how the fish is handled after the catch on board the vessels, how it is preserved packed and transported before it reaches the user. Preservation of the catch from hauling till it is unloaded at the landing centres is the responsibility of personnel on board the vessels. The objective shall be to land the fish in as good a quality as at the time of catch within the limits of practicability under good commercial practice. The fish that is landed is marketed fresh or taken for various types of processing. It is well known that the quality of the end product will depend on how fresh the raw material was and therefore in order to assure good quality for the products it is necessary that extreme care should be taken in preserving the catch by scientific handling on board the vessels. Various factors affect the quality of the fish coming to the land. the main factors being the cleanliness on the deck fish holds, temperature at which the fish is kept packing conditions and mode of handling in general. Good handling of the fish at sea should ensure that the catch retains its natural freshness as far as possible until landing. The important requirements are to clean the fish to make it free from dirt and extraneous materials and chill immediately, prevent its temp. from rising and maintain a high standard of cleanliness during handling. Cleanliness in other words sanitation requires particular attention. The fish should not be allowed to get contaminated with objectionable microbes, chemicals used in cleaning & disinfection metals, paints, oils etc. There are various types of fishing vessels and the main mode of preservation on board the vessels is by icing. However modern big size fishing vessels have facilities to preserve the catch by chilling with refrigerated sea water or by freezing and storing in cold storages. At the same time there are small fishing boats or crafts which have no facilities even for icing. In any case the consumer or the processor is ready to pay a higher remuneration for a raw material of better quality. Since the size and type of fishing crafts vary very much it is not possible to suggest uniform codes of handling the catch. Still a general outline regarding handling preservation of the catch on board the vessel is given below.

Handling of catch shall start as soon as it comes on board. Depending on the gear used the composition of the catch will vary but normally the catch will be of mixed varieties of fish. The catch shall be given a wash with clean sea water to remove the dirt and other debris. The sea water when taken away from shore is generally clean and has only low bacterial load. However it may be chlorinated to a level of 10 ppm available chlorine to make it safe. The washing is very essential as it will eliminate as far as possible the surface bacteria which otherwise will penetrate into the body thereby bringing about early spoilage.

Sorting the fish

The mixed catch has to be sorted out into different varieties specieswise and sizewise. The fish that are not suitable for preservation as human food that is bruised, diseased, decomposed or otherwise damaged shall be separated and either thrown back into the sea or stored separately. This may however be used for conversion into fish meal. Valuable species of fish shall carefully be

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separated and preserved suitably. It may be advisable to sort the catch species wise and sizewise and store them separately in separate containers.

The catch shall never be allowed to remain for long time on the deck exposed to sun. Exposure to sun will elevate the temperature of the fish which in turn facilitates rapid growth of micro-organisms and accelerate the enzymic and bacterial spoilage of the fish. It is observed that the shelf life of fish stored in ice considerably gets reduced if the fish is kept exposed, in the initial stages. Therefore the hauled fish shall not be left on the dock for a long period than required. The fish also shall not be stood upon or subjected to pressure as this will damage the fish affecting the quality adversely.

Evisceration and removal of gills

All reasonably large fish like sharks, Rays, ghol etc may be eviscerated and bled before preservation on board. Bleeding is usually done by cutting the throat and allowing the fish to remain in cold water for about half an hour. Gutting also can be done simultaneously. While gills may be removed the general practice is to leave the head intact. As the gills and viscera harbour inumerable bacteria which can bring about spoilage in the fish after its death, removal of gills and guts will enhance the keeping quality of the fish. However the removal of viscera shall be complete and a thorough washing after the operation is very important as otherwise the exposed belly portion is liable to be contaminated. Similarly if the fish is not bled, during ice storage the blood will clot and become dark brown affecting the appearance of the meat. The operation of removal of gills and viscera as well as bleeding of the fish has to be done separately and other varieties of fish shall be kept away from getting contaminated. After this operation the fish has to be washed thoroughly before it is packed in ice or preserved otherwise.

Preservation of fish on board the vessel

Preservation of fish by ice is by far the cheapest and reasonably efficient method practised on board the vessel. Generally fish can be stored in ice and kept in good condition for a period of 3-15 days depending on the species. Fatty fishes like oil sardine has a short shelf life in ice. The fish easily gets rancid due to oxidation of unsaturated fatty components so also the belly portion gets softened presumably owing to the action of emzymes and bacteria. Hence even at ice temperature the fish remains in good condition only for a short while (2-5 days). For minimising the belly bursting in oil sardines either a dip in brine or sprinkling of salt before icing is recommended.

Fish may be packed with ice in boxes as well as in holds. In small boats fish holds can not be provided and in such cases insulated boxes have to be used. Small size fish are also packed in boxes before stacking in fish holds or pens. This is necessary for avoiding excessive pressure on the fish and resultant damage when heaped in fish holds. However, bigger fishes may be packed in the insulated holds in layers with ice.

Whether in boxes or holds, fish will have to be packed with ice in thin layers. Care shall be taken to provide a thick layer of ice at the bottom, sides and top of the hold or box as heat penetration will be rapid at these areas. Quantity of ice used shall be sufficient to bring down the temperature of the fish and keep the fish at low temperature for sufficient length of time. One kg of ice at 0°C takes 80K calories of heat while melting. The specific heat of fish has been reported as 0.9 and for cooling 1kg of fish by 1°C, 0.9K cal of heat has to be removed. If the fish is at 30°C (room temp.) and it has to be cooled to 0°C (30x0.9) K cal of heat will have to be removed. $\left(\frac{30 \times 0.9}{80}\right)$ kg of ice will be required for this purpose. Therefore theoritically for bringing down the temperature of 1kg of fish from 30°C to 0°C, about 1/3 kg of ice is required. However, in practice at least 50% ice may have to be used for chilling the fish. Generally icing is done at 1:1 level and ice is replenished at intervals to keep the temperature from rising. For icing crushed ice of good bacterial quality shall be used. Finally crushed ice will have more surface area per unit mass and cover more fish, enabling rapid removal of heat from fish. However, for packing chilled fish in holds or boxes, crushed ice in the form of small lumps may be used so as to leave small air pockets within the pack. This will prevent the growth of anaerobic bacteria, causing bilgy odours.

Many species of pelagic fishes such as sardines are easily damaged by pressure. With such fish the shelf life can be enhanced by packing them in boxes with ice both at the bottom and at the top. These boxes are then stacked in the insulated hold. Care shall be taken to see that ice does not protrude above the rim of the boxes as oterwise the fish will be compressed when the boxes are stocked. [illegible] when the boxes [illegible].

Stacking of fish in holds is done by spreading the fish in layers with ice in between. As the fish is a poor conductor of heat for rapid cooling, the ~~thxi~~ thickness of the fish layers shall be kept small. When fish is stacked in holds, the depths of fish and ice shall not exceed one meter. If depth is increased, the bottom fish will start spoiling due to excessive pressure. Care shall be taken to stack gilled fish with belly cavity facing downwards.

Segregation of each day's catch into different lots using coloured paper strips is also advisable. This will help the shore plants to utilise the catch judiciously.

Preservation by R.S.W.

In bigger vessels which stay at sea for longer periods, preservation of fish by refrigerated sea water is adopted. Sea water contains 3-4% salt and hence the freezing point of sea water is around - 1.5°C. The refrigerated sea water tanks installed on board the fishing vessels can chill the fish rapidly as the fish comes in contact with the liquid from all sides and the heat transfer is accelerated. Further the fish remains at temperature of -1° to 2°C throughout. This enhances the shelf life of the fish which can be landed in fresh condition. R.S.W. has been widely used in many advanced countries for preserving various species of fish.

In India also some of the trawlers are installed with R.S.W. tanks. The tanks contain either clean sea water or water fortified with sodium chloride. Depending upon the concentration of salt, the temperature of brine will vary. The brine is chilled by passing over chilling coils and the chilled brine is recirculated in the tank. The fish is dumped into the tank. As the density of fish is less than that of brine the fish will be just floating. The fish can also be suspended in perforated vessels immersed in R.S.W.

R.S.W preservation has been found quite satisfactory in non fatty fish and bigger size fish. Such fishes can be stored in R.S.W. for longer periods than in ice. For non fatty fish like oil sardine, rapid development of rancidity is observed. Meat of some fish like Mackerel gets darkened also. To prevent rancidity, bubbling of carbondioxide through R.S.W. is recommended. Prawn gets black spots easily when preserved in R.S.W. Otherwise it keeps well. Excessive chilling of R.S.W. results in partial freezing of fish. However, this will prevent penetration of salt into the meat. If the temperature is around -1°C only, there is a possibility of salt penetration into the fish during R.S.W preservation. Another advantage of R.S.W. is that more fish can be packed per unit volume.

Freezing Preservation on board the vessel

The shelf life of fish in ice and R.S.W. is limited to a few days only. Generally depending on the species of fish the shell life in ice is only 3-10 days. If it is required to keep the catch for longer period from spoiling on board, freezing will have to be resorted to.

On board freezing is done by employing chilled brine tanks. Highly concentrated or saturated salt solution is used in the tank. The temperature of such solution can be lowered up to -22°C when the liquid will start freezing. The brine is cooled by refrigerated cooling coils and circulated in the tank. The fish or prawn after sorting is taken into perforated plastic bags or bags made of nylon webbings and kept immersed in the cooled brine and allowed to freeze. The freezing time will depend upon the temperature of the brine. Under ideal conditions, freezing will take place in 15-20 minutes when the bags are taken out and stored in cold rooms on board the vessel. For rapid freezing the size of the bags must be small and the brine has to be cooled rapidly and circulated. Such facilities are available in some of the imported steel trawlers operating in our Country.

HANDLING OF PRAWNS

Many of our boats are more interested in the prawn catches as these bring better prices. Prawns as it come on board shall be hosed with clean sea water to remove dirt and debris and shall be stored mixed with ice in 1:1 proportion. Removal of the head before storage in ice is of value in reducing the percentage incidence of black spots. Prevention of free entry of air into the material and avoidance of contamination with copper will also reduce blackspot development. Chemical treatments are also useful. Treatment for 2 minutes in a 0.25% solution of sodium or potassium metabisulfite before storage in ice greatly reduces black spot development. Prawns without any discolouration of the shell or meat are usually packed as headless frozen which fetches the maximum price. Development of discolouration of any sort reduces its value as a raw material. Hence utmost care is required in handling and storage of prawns. One of the early symptoms of spoilage in prawns is the loosening of the head from the 'tail'. Large prawns without any loosening of head is required for packing whole raw frozen prawns. Special care, especially treatment with metabisulfite and storage in finely divided ice and water will help a long way in landing prawns suitable for processing as head on.

It is observed in some cases, that the catch is washed in near shore water at the time of landing probably with a view to impart a fresh appearance. The near shore water is polluted to a great extent with harmful bacteria and several chemicals and toxic substances. Washing the catch in such water will definitely be a health hazard and it shall not be practised.

WATER SUPPLY

All fishing vessels should have arrangements for a copious supply of bacteriologically sound water. It is difficult for vessels to carry very huge volumes of water on each fishing trip. However it is possible with a pump arrangement to supply enough quantity of clean sea water. Sea water from open sea is of sufficiently pure bacteriological quality. Water is required to clean the deck, the fish hold containers, the catch etc. Arrangement for chlorination can also be made. Presence of small amounts of available chlorine in the water is a guarantee against high bacterial loads.

2) ICE

All fishing vessels irrespective of their size shall carry ice. Ice prepared from potable water chlorinated to 10 ppm available chlorine is prefered. Ice is required to cool and preserve the catch. There shall be a proper insulated store for ice. In smaller boats, ice may be even taken in insulated boxes.

Ice manufactured from clean seawater can also be used. Seawater usually contains 3% sodium chloride and the temperature of the ice will be 30-32°F compared to 32°F for fresh water ice. In other words seawater ice is a better coolant than fresh water ice. But there are certain difficulties in its manufacture and use. If seawater is frozen as block ice, the distribution of salt will not be uniform. If flake ice is made, this defect is rectified. Fish may absorb the salt, making it unsuitable for certain types of preservations. It may also be difficult to keep the fish at constant temperature with seawater ice because of the leaching of the salt.

Ice - whether fresh water or seawater - shall be stored and handled under hygienic conditions. Ice shall be stored on platforms when separate store room is available, so that the melt water can drain off. Ice shall not be dragged through the deck etc from the store. Ice crushing machines shall be properly cleaned and hyginnically maintained.

Ice left over after a fishing trip shall not be used in the next trip; even if unused. The reason is that the bacteriological quality might have suffered greatly during the trip and the chances for build up of psychrophilic bacteria are more.

3) FISH HOLD

Wherever practicable, the fishing vessel shall have a fish hold, The hold shall be constructed in such a way that it is readily accessible for cleaning and disinfection. The material of construction shall be non-corrodible and shall not impart colour or odour to the fish. Wood is generally used in boat construction and in such cases the hold may be lined with a suitable non-corrodible material.

The fish hold shall be sufficiently insulated and shall be divided into pounds or pens not more than 1.4 x 1.4 meters.

There shall be sufficient drainage facilities in the hold, so that the ice melt water and other liquid wastes are discharged into a central drain. Fish hold lining should be completely water tight. When chutes are provided for discharging fish to the hold, they shall be fitted in such a way that fish do not have to drop more than 1m into the hold. All surfaces coming in contact with fish shall be made of non corrodible material.

In very small boats provision of fish hold is difficult. In such cases, sufficient number of storage containers may be used.

Refrigerated seawater or refrigerated brine may also be used in many cases in place of ice. The advantages are 1) more fish to unit volume 2) lessening of physical damage 3) easiness in handling etc. The greatest disadvantage is the absorption of sodium chloride by the fish.

4) CONTAINERS

All containers used to store fish shall be constructed of non corrodible material. Baskets of bamboo etc are not to be used as they are very difficult to clean and sanitize. The construction of the containers shall be in such a way that it is easy to clean and dis infect, that they can be stacked one above the other conveniently without the ice melt water falling into the container below. The usual boxes are of wood, marine grade aluminium and high density polythene. Wood, when used shall be planed and coated with rot resistant paint. Otherwise wooden boxes are to be used only once. Boxes of aluminium are good but they make sound. High density polythene containers do not stand the stress and strain to the extent possible by aluminium.

5) CLEANING AND DISINFECTION

A proper method of cleaning and disinfection shall be followed regularly on board. All equipments, utensils, fish hold etc shall first be made slime free by scrubbing with a brush after spraying a suitable detergent. Teepol at 0.5% concentration is good as a detergent. To the slime free surface a suitable disinfectant shall be sprayed. Chlorine is most suitable. For metallic surfaces water containing 100 ppm available chlorine may be used and for wooden surfaces the dose can be upto 1000 ppm. After a contact period of 15 mts. the disinfectant may be washed off with clean water.

Water under pressure though a hose can also be used with the specified levels of detergent and disinfectant. Such washing may be done at the start of a fishing trip and after unloading the catch. On the deck it maybbe followed before unloading the haul and after the deck is cleared. Improper cleaning will result in build up of slime and bacteria which will contaminate the catch.

PERSONNEL HYGIENE

All persons engaged in handling of the catch on board shall be free from communicable diseases. Medical check up, atleast once in every three months is advisable.

All the persons engaged in handling of the catch shall wear clean uniforms including headwear. Water proof coats or aprons and gloves shall be usdd as and when required.

Adequate hand washing facilities shall be provided. Before haddling the catch, workers may wash their hands from elbow down using soap followed by disinfection in 200 ppm chlorine. They may repeatx this after visits to toilets, after break in work or at any other time their hands are contaminated. In several cases it is noted that the palm ofthe workers harbour certain micro-organisms which are not to be present in a food product. That is why importance is attached to hand washing and disinfection.

It will be also advisable not to smoke and chew tobacco etc when handling the fish.

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HANDLING, PRESERVATION AND TRANSPORT OF FISH

B y

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INTRODUCTION

The low level of fish consumption in India is mainly attributable to the uneven distribution of fish within the country due to lack of preservation and transportation facilities for movement from the landing centres to the interior regions. The fish landing centres of India are scattered along its 4800 Km long coast line. Inspite of the rapid progress made in the field of fishing and fish processing, the pattern and distribution of fish in India continued to remain more or less unchanged. Efforts made by the Government and private industry are primarily aimed at utilizing prawns which constitute 10-12% of the total marine landings and which continue to possess the export potential. Commercially important fishes like oil sardine, mackerel, tuna and pomfret are frozen in a limited scale in some of the freezing plants in the country as means of preservation for local consumption. Insufficient knowledge of technological problems peculiar to the tropical varieties of fishes is largely responsible for apparent inhibition by the processers in utilizing these fishes into frozen products. Recently attention has been turned to the handling, distribution and preservation of the marine fishes and fresh water fishes within the country. Employment of quick means of transport such as trucks and vans has to some extent helped to ease the situation and more fish now find their way to interior markets. A few refrigerated rail wagons have beenintroduced along selected routes for transportation of fish into interior cities. However, the quantity of fish handled this way is negligible compared with the vast surplus available for distribution especially during heavy fishing seasons.

FISH SPOILAGE AND TEMPERATURE

Fish is a highly perishable material and it undergoes autolytic, microbiological and chemical decomposition soon after its death. The mechanism of these changes has already been dealt with by the earlier speaker. Spoilage rate is dependent mainly on the temperature condition under which the fish is stored. The spoilage rate of fish at -1°C to 2.5°C varies linearly with temperature and it is twice as fast at 2.5°C as at -1.1°C, at 5.5°C and at 11°C it is twice and four times as fast as at 0°C. Hence the temperature of fish should be kept as low as possible in order to maintain the quality. As the ambient temperature in many parts of India are often above 3°C in summer, proper refrigeration of fish is very important during different stages of handling, storage and distribution.

ICING OF FISH

Ice as a cooling medium for fish has a great deal in its favour, it has a very large cooling capacity for a given weight or volume, it is harmless, portable and cheap. Very rapid cooling is possible through intimate contact between fish and small pieces of ice. Ice keeps chilled fish cold, moist and glossy and prevents deterioration that would accompany other materials of cooling. In use, flake ice has some advantages over crushed block ice in that the pieces are smaller, cause less indentation and melt more rapidly. Tube ice has properties somewhere between the two. It is doubtful whether the differences are sufficiently great to outweigh other considerations such as size of plant required and the cost and speed of production. For very large processing plants, it is likely that block ice manufacture may be still the most economical but for moderate quantities in remote localities, the small ice plant may very well be the answer.

Chilled fish stored in ice in close contact with every fish will remain at the temperature as long as some of the ice still remains. When iced fish is kept in chill room, care must be taken that the ice is not kept so cold that it cannot melt at all, in which case partial freezing can occur and the fish will lose the glossy appearance that is normally provided by melt water. Ice cold water removes heat from the fishes effectively because it comes into contact with all parts of fish. The boxes used for stacking fish with ice must be kept thoroughly clean to prevent contamination of fish by spoilage/disease causing bacteria. All surfaces coming in contact with fish must be rinsed thoroughly with water containing detergent/disinfectant and then with fresh water to prevent corrosion and to avoid contamination of fish with disinfectant.

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RIGOR PROBLEMS IN HANDLING FISH

Small fish with low reserve's of energy that is exhausted and in poor condition and kept at a high temperature will enter and pass through rigor very quickly. On the other hand, large, rested and well fed fish kept at a low temperature will take long time to enter and pass through rigor. Rigor problems are not usually met with in the bulk of chilled wet fish landed at the ports because the fish would have already passed through rigor while in ice or on board fishing vessel. Rigor can affect the quality of whole fish by causing gaping in wet and frozen fish and toughness and excessive drip loss on thawing in frozen fish. The safest and most reliable way of avoiding the undesirable effect of rigor is to keep the fish chilled at every stage before freezing.

STORAGE CHARACTERESTICS OF FISH HELD IN ICE

Storage characterestics of commercially important varieties of fish and shell fish of India have been studied in detail and much published data are available on the subject. The extent of spoilage and accompanying chemical changes occurring in fish held in ice vary considerably. In the case of ice stored prawns, soluble nitrogenous constituents are progressively lost from the muscle, the changes being remarkable during the first 8-10 days of storage in ice. Glycine, the aminoacid which imparts sweet flavour of fresh prawns is rapidly lost andso also minor compounds like sugars, sugar phosphates, nucleotides etc. which are involved in flavour. The loss of solids through leaching action of ice depends on the form in which the fish is packed in ice; with peeled deveined prawns, the loss of solids recorded as high as 30% of the original weight of the muscle, the loss in weight being partially compensated by the uptake of water from ice.

Ices containing antibiotics such as Chelotetra Cycline and oxytetrecycline say at 5 ppm level offer advantages over ordinary ice by extending keeping quality. Use of higher levels of CTC in ice is not advisable since it would result in higher amounts of absorbed CTC in fish muscle which is not completely destroyed during cooking. The effect of antibiotic becomes pronounced only after a week's storage and hence can be taken advantage by the distant water fishing fleets when the fishing trip extends beyond one week. The residual preservative effect of the antibiotic on fish is manifested when repacked in ordinary ice during inland

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distribution when spoilage might continue to be retarded. However, the small but definite improvement in quality of earlier caught fish has to be weighed economically both against the possible loss of prestige of fish if this comes to be regarded as an adulterated food since its use has yet to be cleared by Public Health Regulations.

TRANSPORTATION OF FISH AND CONTAINERS

The mode of transport of wet fish depends upon the distance to be covered, the quantity of fish to be transported, the facilities available for quick and safe despatch and the expenses that will be incurred. Bamboo baskets are universally employed in fish transport their capacity varying from 15 to 50 Kgs. Wooden boxes are used for long distance transport of fish. In many parts of the country, second hand tea-chests made of plywood are used for thie purpose. These containers are cheap but have poor insulation properties. Aluminium and galvanized iron vessels are used for transporting iced fish to the processing plants.

Improvements have been effected to the conventional bamboo baskets by providing additional insulated linings with bitumen - coated Kraft paper or gunny and polythene. Experiments have shown that shelf life of trash fish like sardine, mackerel, jew fish etc. is considerably enhanced when packed in ice in these containers. However, during transport, it is observed that the middle layer of fish is comparatively at lower temperature than at top or bottoms layers. Providing additional layers of ice at the top and bottom would ensure better and uniform quality of fish throughout.

Non returnable container is used mainly for carrying wet fish and ice between landing place and retailer often through an inland wholesaler. The container is required to protect the contents throughout one single journey against damages or loss and to keep the fish the wholesome. After the journey has been completed, the container is discarded. Returnable containers despatched to retailers scattered all over the country are extremely difficult and expensive to recover.

A more sophisticated container developed by CIFT for long distance transport of fish (both iced and frozen) consists of a plywood box - a second hand tea chest insulated with thermocole. Thermocole slabs 20 or 25 mm

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thick are cut to internal measurements of the box, sealed in polythene bags to prevent the thermocole from coming in contact with melt water and placed in all the sides in the box. The boxes are finally wrapped with gunny cloth to give additional strength and protection against damage in transit. The following table illustrates the performance of the different containers.

Storage of iced fish in different containers.
Ratio of fish to ice 1:1
Ambient temperature 26-32°C
Maximum storage temp. attained 3-5°C

Container	Maximum storage (hrs)
Bamboo basket	0 - 10
Bamboo basket lined with Kraft paper	16 - 17
Bamboo basket lined with gunny and polythene	16 - 18
Plywood box (plain)	14 - 16
Plywood box lined with 25 mm thermocole	50 - 55

The plywood boxes (second hand teachests) of dimension 48.2 x 48.2 x 58.5 cm (110 Kgs) and 45.5 x 45.5 x 51.5 cm (80 Kgs) were extensively tried in the field under the Research Programme on All India Coordinated Research Project on Transportation of Fresh Fish.

The effectiveness of the insulation materials can deteriorate in service and it is recognised that the efficiency of the insulation should be assessed periodically to ensure an efficient and economic distribution system.

VEHICLES USED IN FISH TRANSPORT

Vehicles used for transportation of iced fish to markets/processing plants in India are either open, closed (uninsulated) or insulated trucks; of these open and closed (uninsulated) trucks account for about 75% of the total number. Therefore the number of refrigerated and insulated vans is inadequate to meet the country's requirement. It has been brought out that almost twice as much ice has been used in case of transport in uninsulated trucks as compared to transport in insulated trucks. It is estimated that two tonnes of ice are used in uninsulated trucks for every

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tonne of raw fish as against one tonne in insulated trucks. It also decreases the capacity of trucks since two thirds of the space is occupied by ice alone in open or closed uninsulated trucks. In the case of insulated trucks, only half the space is occupied by ice.

HANDLING AND TRANSPORTATION OF FROZEN FISH

The quality of frozen fish depends on the length of storage and storage temperature. Any adverse storage condition at any stage of distributi will result in loss of quality. Even short periods of high temperature could cause deterioration; for e.g. it has been shown that if fish being stored at -18°C was allowed to rise to -9°C for three days and then cooled again to -18°C, the storage life would be reduced by 6 weeks. It is therefore essentia to maintain the temperature of the product at a minimum during distribution and also to prevent temperature fluctuations. The warming up of frozen fish during transport should not be confused with thawing or defrosting. Thawing takes place slowly and can be easily seen happening as the fish becomes moist and soft. The warming up of frozen fish from -20°F to 20°F can take place comparatively quickly with no obvious sign of change. The 'warm' package remains hard and looks and feels exactly as it was at the low temperature but nevertheless the fish is deteriorating much more rapidly. The only way of denoting change is by measuring the temperature of fish. Refrigerated insulated vehicles are to be used for long distance transport of frozen fish. At present the industry possesses only a few refrigerated trucks, the bulk of frozen fish (mostly frozen prawns) is transported in insulated trucks from the factory to the wharf for shipment. Wide fluctuations in the temperature of frozen material have been observed during transportation for shipment. In a typical case it was observed that while transporting frozen prawns, the main item of export, in insulated trucks when the ambient temperature was 24-26°C the temperature variation observed at the top surface, bottom surface and centre of the frozen block in master carton placed near the door of the truck was -15°C to -3°C, -15°C to -7°C and -15°C to -10°C respectively during the first six hours of transport. The main fluctuation in temperature of frozen prawns take place during loading from the cold store in the factory to the truck which usually takes 30 to 60 minutes and during the loading from the truck into the ship at the wharf where the delay may be

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anything between 0 - 8 hours. It is to be borne in mind that the final thawed quality reflects all the time - temperature history of the product during its shelf life.

USE OF SOLID CARBONDIOXIDE OR LIQUID NITROGEN IN TRANSPORTATION OF FISH

The function of the refrigeration system in the truck is to absorb the heat as it comes through insulation and not to cool the load. The refrigerants used commonly are solid carbon dioxide, liquid carbondioxide, liquid nitrogen mechanical refrigeration, eutectic plates. Each system has its own characteristic with advantages and disadvantages. The actual choice of any system is based on its technical efficiency and economics applied to a particular operation. In order to take full advantage of the cooling medium, an air space atleast 1-2" should be left between the frozen cargo, floor, walls and roof of the truck. This space should allow cold air to circulate around the whole of the cargo and return to the source of the cold. The heat coming in through the insulation will then be carried to the cooler and absorbed before it reaches the contents of the truck. In India, solid carbondioxide (dry ice) or liquid nitrogen is not at present used in the transportation of fish although some work has been done in this field. One of the reasons for not using solid carbondioxide or liquid nitrogen is the prohibitive cost of these cooling agents in India.

IRRADIATION PRESERVATION OF FISH

It has been recognised from laboratory experiments that many fish and fishery products can be preserved by irradiation. Radiation pasteurization or radurisation at doses of 0.3 - 0.5 M rad or less can provide worthwhile extension of shelf life without detectable undesirable changes. Bacteriologically the effect of irradiating fish are to kill large proportionsof bacteria which cause spoilage, that is those of genus pseudomonas. For distribution of irradiated fish, some kind of protective package is necessary at least as far as retail distribution is concerned. Packaging of fish in an impermeable film sealed under vacuum and irradiated at 0.3 M rad could offer greatest extension of shelf life. The shelf life of fish in a vacuum pack is governed by the quality of fish before packaging, the

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bigger advantage being obtained with fresh fish. Radurisation of fish is not commercially feasible at the moment. Although the advantages claimed are expansion of market area, improvement of quality, reduction of spoilage losses, facilitation of distribution and reduction of transport and handling costs. However there is potential danger that the health hazard has been increased particularly with respect to the spore forming organisms which are more resistent to irradiation than spoilage bacteria. In India, the use of irradiation as applied to fish preservation has not been cleared by the Health Ministry.

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FREEZING OF FISH AND SHELL FISH

By

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Freezing is one of the important methods for preserving food. Artificial freezing of fish on a commercial scale in United States began about 1865 and in India in 1953. In our country fish is mainly frozen for export and only a small quantity of the frozen fish is consumed within the country. Of the export earnings from fish and fish products about 85-90% is constituted by frozen fish and shell fish alone.

During the freezing process the temperature of fish is lowered below -1°C so that most of the water present in fish is converted into ice and the fish is preserved for longer periods without deterioration. Different methods are now employed for freezing fish and fishery products and many varieties of fish and shell fish are now preserved by freezing.

FREEZING METHODS

1. Freezing in cold air:

There are two types of air systems for food freezing - still air and forced air. Still air freezing is accomplished by placing packaged or loose food in suitable freezing rooms or cabinets. Still air freezing is the cheapest method and the slowest. Products remain in the freezing chamber until frozen. The freezing time will depend upon so many factors like temperature of the cabinet, type of food being frozen, initial temperature of the material, type of the food package and arrangement of packages in the freezer.

A refinement of the above method is to place the fish on shelves or in trays in intimate contact with cold pipe grids arranged below them. Cooling in this case is partly by contact with cold pipes and partly by still cold air.

2. a) Tunnel freezing:

In this type of freezing cold blast of air (-35 to -40°C) is circulated at high velocity over the fish either individually or in packages or trays. The fish is usually frozen as batch and the freezing time for one

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batch will be 4 to 6 hours usually. In this case freezing is quicker and large quantities can be frozen in limited time. But surface desiccation is a problem especially when unpackaged products are frozen in the tunnel freezer.

b) Fluidizing tunnel freezers:

In the past few years the principle of fluidising has been applied to many processes and in the refrigeration industry it was first used for chilling/freezing of peas. In the fluidizing freezer the product to be frozen is individually suspended in the upward flowing cold air stream of the freezing tunnel and hence the best possible heat transfer is achieved between the air and the product. In the fish industry fluidizing has been applied to shrimp freezing and is suitable for freezing small fish and fillets. The advantages are (1) freezing is very quick (2) no distortion of shape and the original appearance is not lost. The freezing time for shrimp and small fishes is usually 6-12 minutes.

3. Freezing with liquefied gas

Liquefied gases which can be used for freezing include air, nitrogen and carbondioxide. The properties of these gases are given below:

Name of gas	Boiling point °C	Latent heat K.Cal/Kg.	Specific heat
Nitrogen	-196	47.4	0.248
Air	-194.2	48.8	0.241
Carbondioxide	-78.5	136.8	0.202

The freezing by liquefied gases is very quick, but the systems are expensive. Initially immersion systems were used for freezing food stuffs but now spraying techniques have been developed. The liquefied gases are also used as a supplementary cooling agent in the transport of frozen cargo or maintaining the low temperature in fish holds. Solid carbondioxide is used for transporation of frozen fish by air.

4. Contact freezers:

Contact plate freezers are probably the most efficient in current use. Two types of contact plate freezers are commonly used (1) Horizontal plate freezer (2) vertical plate freezer.

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Horizontal plate freezers

These freezers have their plates in the horizontal plane. Fish is contained in aluminium or galvanised iron trays with lids and these are placed between adjacent plates cooled by refrigerant and maintained in contact with them by slight hydraulic pressure. The normal opening between plates varies from 25 mm to 75 mm. The temperature of freezer will be -35 to -40°C and the fish will be frozen within 2 to 2½ hrs.

Vertical plate freezers:

Vertical plate freezers are commonly used for freezing fish on board fishing vessels. The advantages are that no trays are required, their operation is simple and for a given out-put they require less space for installation and operation than any other freezer at present at sea. With a refrigerant temperature of -40°C and the optimum circulation rate freezing time as low as 2½ hours have been recorded on 100 mm blocks.

5. Rotary drum freezer:

This is a revolving drum freezer developed for the individual quick freezing of fillets, shrimp etc. These are fed by a conveyor on the external surface of revolving stainless steel drum held at a low temperature. Here the material immediately adhere by the freezing of water. At the end of one revolution the frozen product is scraped off and passed through an automatic glazer for packaging. As there is no air movement and freezing is very rapid there will be no loss of weight during freezing.

6. Immersion freezing:

Freezing in brine:

In the immersion freezing intimate contact is assured between every surface of the fish and the freezing medium and hence the heat transfer will be very efficient. The only freezing medium which has found favour is sodium chloride brine and this has the eutectic point of -21.2°C and in practice this medium cannot be used below -18°C.

Brine freezing has been used in the U.S. west coast tuna purse-seiners. Brine freezing is also used for sardine and shrimp andhas been suggested for mackerel and herring. The conventional method used for

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brine freezing of tunais to cool it first to -1 °C in chilled sea water. Salt is then added to sea water to produce brine of about 1.126 specific gravity and with a freezing point of -13.5°C and fish is allowed to remain in the chilled brine until it is frozen and removed.

Salt penetration is a disadvantage of direct brine freezing. The fish will take up salt resulting in reduced keeping quality and in a few cases off-flavours. Salt penetration is serious only when the fish are held in brine (23%Nacl) for longer periods and when the brine temperature is not held below -12°C. The fish held in chilled brine after freezing continue to absorb salt.

The excessive salt penetration occurring during brine freezing can be reduced by using a mixture of glucose syrup or corn syrup and salt as the freezing medium. The glucose - salt freezing solution will give a protective glaze to the frozen product and the frozen material will not stick together.

The following method can be used for the brine freezing of prawns. (1) use freshly caught whole or beheaded shrimp (2) wash the prawns thoroughly with ice cold water (3) maintain the brine below -12°C (4) put the prawns in plastic net bags and immerse into chilled brine (5) remove the frozen prawns after freezing into the frozen storage.

7. Brine spray freezing:

Instead of immersion freezing, brine spray freezing can also be used for freezing fish on board fishing vessels. In this method chilled brine is sprayed over the fish placed in trays or boxes and the heat from the fish is removed by the chilled brine and the fish gets frozen within 1-2 hrs.

8. Freezing the liquid refrigerant -12 (Dichlorodifluoro methane)

A recent development in the United States is the freezing of high value products by immersion in Refrigerant -12. The heat transfer rates are stated to be double than for liquid nitrogen and the costs are much lower.

Freezing fish at sea:

The storage life of fish in ice is limited and hence fish is preserved by freezing on board fishing vessels when the voyage lasts

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for a few weeks or months. Fish is either frozen in brine or in blast freezers or using vertical plate freezers. The fish is frozen immediately after catch by one of the above methods and stored in the cold store of the vessel. On reaching the shore, the frozen fish is thawed and converted into other products.

Changes during freezing and storage of fish

Physical changes

(1) Ice formation: The formation of ice crystals starts when the temperature of the fish is lowered to about -1 °C and at the same time the concentration of various organic and inorganic components in the tissue fluid increases. Consequently the freezing point falls. The temperature of the fish must be therefore lowered further before additional water freezes.

There is also an increase in the volume of fish when it is frozen. At -3°C about 70% of the water is frozen , at -5°C about 85%, at -25°C about 95% and at -50 to 60°C almost all the water in the fish is frozen. Thus the largest part of water freezes between -1 and -5°C and this zone is called the zone of maximum crystallisation.

Freezing rate:

Slow freezing results the formation of large ice crystals. These can cause the tissue of fish to become more porous and it may even become spongy. Rapid freezing on the other hand results in small ice crystals and the quality of quick frozen fish will be definitely better than that of slow frozen fish. Thus the rate of freezing has been considered very important for obtaining high quality product. Microscopic examination also shows that slow freezing results in greater destruction of the tissue than quick freezing.

Theories of the effect of freezing led to the conclusion that large ice crystals formed by slow freezing are able to penetrate the cell walls resulting the large drip loss when the fish is thawed than when the fish is quick frozen. But further investigations and application of modern techniques have shown that the changes occurring in freezing and thawing are caused by the irrevisible changes in the colloidal state of proteins induced by the increased concentration of dehydrates in the unfrozen part of the fluid in the fish tissue.

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Desiccation:

Desiccation from the surface of the fish takes place during freezing and frozen storage. The greater the temperature differential between fish and evaporator and greater the velocity of circulating air, the more will be the moisture lost. Moisture loss will be more at higher storage temperatures and the fluctuation in storage temperature also influences the loss in weight and quality of the fish. The loss in weight due to desiccation can be reduced considerably by giving the frozen product proper glazing and/or suitable packaging.

Toughness:

Freezing increases the toughness of fish muscle and the toughness increases during subsequent storage. The increase in toughness is due to the changes in proteins during freezing and cold storage, due to dehydration (desiccation) of fish muscles etc.

Discolouration:

Some fish (e.g. tuna, swordfish etc.) exhibit green and brown discolouration on freezing and cooking. The pigment responsible for the pink colour of cooked tuna meat is hemochrome formed by the reaction of myoglobin with non-heme constituents. Browning is due to the formation of metmyoglobin in the muscle due to autoxidation of ferous myoglobin. Greening is caused by the presence of pigment formed by the oxidation of hermochrome. Discolouration during frozen storage can also be observed due to the oxidation of fat present in the fish.

Changes in fat

Most fishes contain considerable amounts of fat in their body. During frozen storage fat undergoes changes resulting in the development of rancidity. The most important change taking place in fat during the frozen storage is the oxidation leading to rancid odours and flavours and hydrolysis producig fatty acid. These are responsible for off odour and off flavour in fatty fishes and textural changes in lean fish. The fish lipids are highly unsaturated and these unsaturated fats undergo oxidation by the free radical hydroperoxide chain reaction and various products like aldehydes, ketones and other compounds are formed.

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Glazing and packaging are the common methods of preventing rancidity during frozen storage. Very low temperature of storage slows down the development of rancidity. Permitted autoxidants like butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT), gallates etc. are also used for controlling the development of rancidity.

Drip

Drip is defined as the exudate of tissue fluids that flow free from fish muscle during thawing of frozen fish or muscle. Drip leaches along with it soluble proteins, vitamins, minerals and gives an undesirable appearance to the thawed fish. Drip was regarded occurring as a result of cell damage caused by freezing. But cell damage alone cannot account for the release of drip and it is also related to the capacity of the muscle proteins to imbibe free liquid.

Protein denaturation:

The most important biochemical change associated with protein during freezing and cold storage is denaturation. In general denaturation may be defined as any modification in the structure of protein molecule. The structural modification may bring about definite changes in chemical, physical or biological properties of proteins. During frozen storage the rate of protein denaturation was found to depend on various factors such as storage temperature, state of rigor at the time of freezing, freezing rate and thawing time. Amount of extractable proteins is often taken as a criterion of denaturation. It has been reported that during frozen storage the extractability of the myofibrillar group of proteins is decreased whereas the extractability of the sarcoplasmic proteins is unaffected. The loss in the characteristic texture due to decrease in water holding of myofibrillar protein brings about drip loss in some varieties of fish such as cod and Bombay duck.

The lipid constituents of thefish muscle have an important influence on the stability of proteins. There is a good correlation between protein extractability and rise in the amount of free fatty acids in case of many fishes.

Microorganisms

Cooling prevents or reduces the growth of bacteria and if the fish temperature is low enough many bacteria will not grow at all. Low temperature has a lethal effect on some bacteria and no effect on others. Freezing therefore does not sterilize the product. Although most of the bacteria may be destroyed there will always be some which are not killed during freezing. As soon as the product is defrosted, these microorganisms will proceed to grow.

In the case of fish, in general, freezing causes an initial drop in the number of bacteria present of the order of 60 - 90% and if the storage temperature is below the minimum for growth, there is a gradual drop in the number of bacteria during storage. The heavier the initial load the greater the number of survivors. Microorganisms such as gram-negative types can survive freezing and freezing does not seem to change the properties of microorganisms. The most susceptible form of microorganisms are the vegetative cells and spores are not usually injured by freezing.

According to some workers slow freezing appears to be more effectiv in destroying bacteria than rapid freezing, but slow freezing is not recommended since bacteria may have time to develop and grow before the temperatu becomes inhibitory, resulting in undesirable effects on textural qualities of the fish.

Protection, wrapping and glazing of frozen fish

Careful protection of frozen fish is necessary to prevent or reduce loss of weight, desiccation, development of rancidity and loss of colour etc. which may take place during freezing and cold storage.

Glazing:

Glazing with water is one of the oldest methods of protecting frozen fish. Three principles have been adopted (1) frozen fish or fish block dipped into ice cold water and the water freezing as a cover shell (2) The frozen fish may be sprinkled with cold water (3) fish is frozen

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with water so that a compact block is formed. The latter method is adopted in the case of block frozen shrimp and fish fillets. If fish is individually frozen, it must be dipped several times to obtain a sufficiently thick glaze or must be sprinkled repeatedly.

Water containing antioxidants, sugars, alginates, glutamates etc. are also used for glazing fish.

Wrapping:

Proper wrapping also protects the frozen fish and extends their shelf life. The common packaging material used are polythene, waxed papers, plastic coated papers, aluminium foil, saran etc. In the prawn freezing industry, the frozen glazed prawn blocks are wrapped with polythene paper and packed in waxed duplex cartons. The blocks packaged like this are again packed in master cartons made of corrugated fibre board for storage and export.

Thawing of frozen fish:

Frozen foods are generally thawed in air or in water. Dielectric heating is also used for thawing frozen foods. Dielectric thawing reduces the time required for defrosting. In this method the frozen material is placed between two metal plates but without touching them and the plates are connected to high voltage source which is alternating at a frequency of several million cycles per second, energy is produced in the material in the form of heat.

In thawing large fish or frozen fish blocks water thawing is preferred. Thawing in water is carried out by immersing the fish in tanks of water or by sprinkling. In air thawing circulation of air is recommended in order to reduce the thawing time. The temperature of water or air should not be so high as to be detrimental to fish quality. When thawing is carried out in circulating air, it is important to prevent the fish surface from drying out. When thawing in water fish should be prevented from absorbing too much water. Air thawing is suitable for small size fillets, but in the case of large fillet blocks spraying with water is recommended.

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In electrical resistence thawing fish is placed in between two electrodes and a low voltage current is applied so that current flows throug the fish. In this method it is very difficult to achieve even heating unles the item is homogenous and regular in shape. Good results are obtained with fish fillets and blocks. During thawing of fish, drip loss occurs and some of the nutrients are lost in the drip.

Refreezing of frozen fish

Since fish can be stored in ice only for limited length of time and prolonged storage of fish in ice adversely affects its quality, fish is usually preserved by freezing on board fishing vessels when the voyage lasts for a few weeks or months. On reaching shore these frozen fish are thawed and reprocessed. This allows better planning of work in shore plants and reduces operation at sea.

Manufacture of fillets by refreezing of thawed whole fish bulk frozen on board and refreezing of prawns into as blocks or individual quick frozen samples using thawed prawns frozen at sea are common practices. As far as quality is concerned, refreezing of fish has always been considered undesirable. But if freezing and thawing are carried out rapidly, refreezing results in no major impairment in quality.

Norwegian studies have confirmed that an acceptable quality of frozen fillet is obtained in the case of refreezing whole frozen and thawed fish. Lean fish, however, exhibit considerable loss in quality, especially as fillets, when refrozen, the texture becomes tougher. Fatty fish such as red fish and cat fish withstand such treatment better.

Considerable loss in quality has been observed during refreezing of frozen and thawed prawns. The loss of nitrogenous compounds was more in the case of double frozen samples and the thawed yield was less in double frozen samples compared to once frozen samples.

Storage, transportation and distribution of frozen fish

After freezing the frozen fish are packed properly and stored in a cold store at low temperature. Temperature at the -23°C level were long considered fully satisfactory for long term frozen storage as the microbiological activity is arrested at this temperature, but the chemical reaction continue to take place in the fish tissue at a considerable rate even at this low temperature of storage. This is specially seen in the case of fatty fishes. It is known that lowering of temperature by 10°C at the -10°C level induces a fourfold increase in shelf life whereas at the -20°C level a 10°C reduction in the temperature doubles the shelf life.

For long time storage especially in the case of fatty fish -30 to -35°C is recommended for frozen fish.

The fluctuation in storage temperature also adversely affect the quality of frozen fish. Minor fluctuations in temperature (1 to 2°C) resulting from the periodic operation of the refrigerating machines have no effects on the quality of frozen fish. But fluctuations of the order of 5 or10 have got definite detrimental effect. It is understood that fluctuations at the temperature level of -30°C have less effect, but that at the -10°C level and above they are detrimental.

Fluctuation of temperature of frozen fish also takes place during transportation and distribution. Transportation of frozen cargo is done either in refrigerated vehicles refrigerated rail wagons or in insulated vans. Temperature of frozen cargo rises during loading (from the cold storage in the factory to the truck) and during transportation. Temperature fluctuations as high as 10°C have been observed in certain cases. Solid carbon dioxide can be used to maintain the temperature of frozen cargo during transport and distribution.

Freezing of fish

Whole fish:

Small size fishes like oil sardine , mackerel, lactarius etc. are frozen as whole. The fish are first washed in potable water and frozen as blocks of convenient size (e.g. 2 kg) after adding glaze water. The freezing is done in contact plate freezers or tunnel freezers. The fish will be frozen within 2 - 3 hours and after freezing the material is removed from the freezer, reglazed, packed and stored in a cold storage at -23°C.

Large fish to be frozen are first evicerated and washed thoroughly in potable water. In some cases head and gills are also removed. These

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fishes are frozen individually in tunnel freezers or plate freezers. On board fishing vessels brine freezing are also adopted for freezing fishes like tuna etc. The freezing time is dependent on the size of fish and the method adopted for freezing. After freezing the fish is glazed, packed in boxes and stored in the cold storage at -23°C or below.

Fish fillets:

Fillets are the strips of flesh cut parallel to the back bone of the fish. Fillets may be with skin or without skin. The belly flaps are usually separated from the fillets as the belly flaps tissue may discolour during frozen storage. In many developing countries the head and belly flaps will find a ready sale on the subsistence market and the fillet will fetch a much higher price in the luxury market. The different steps involved in the production of frozen fish fillets are:

1. Grading, washing and weighing of fish
2. Evisceration and scaling and washing
3. Filleting, trimming and washing
4. Treatment, if any, to improve texture, quality etc.
5. Packaging and freezing
6. Packing in cases after freezing, sealing, code marking and storage at -23°C in the cold store.

The following fishes are found to be suitable for filleting: Perch, Indian halibut, ghol, jew fish, hilsa, chanos, mullets, cat fish, thread fin bream, carps, pomfrets, seer and ribbon fish.

Filleting can be done by hand or using machineries. None of the machines is capable of filleting all varieties and all sizes of fish. The yield of fillets depends upon the fish species, filleting methods etc.

The fish fillets are usually lightly brined by dipping in salt solution for a short time prior to freezing. The advantages of this process are (1) to wash the fillets (2) to decrease drip loss during thawing of fillets (3) to give the fillets a pleasing salty flavour. Brining accelerates slightly the development of rancidity in fatty fishes. Hence fatty fish fillets are seldom brine treated before freezing.

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Phosphate treatments are also used for reducing drip loss in frozen fillets. The fillets are packed in the following way for freezing.

1. Individual fillets wrapped in a flexible film.
2. Fillets frozen as blocks with or without glaze water and packed in polythene lined cartons.

The freezing is done either in a contact plate freezer or in a tunnel freezer at -35 to -40°C. The frozen fillets are packed in waxed cartons and stored at -23°C.

Fish chunks or pieces

Large fish are cut into small pieces or chunks and frozen individually, wrapped and stored.

Minced meat:

Minced meat is prepared from filleting wastes or from other cheap varieties of fish which are not directly used for canning or freezing. The meat is separated from the gutted and cleaned fish by using meat picking machines. The picked meat is packed in cartons or trays and frozen in a contact plate freezer or blast freezer and the frozen product stored at -23°C.

Freezing of shell-fish

Shell fish which are commercially frozen include prawns, lobster, crab, clams, mussels etc.

Prawns:

The main commercial species of prawns caught and processed are Penaeus indicus, Metapenaeus dobsoni, Metapenaeus affinis, Metapenaeus monoceros and parapenaeopsis stylifera. The prawns are frozen in different forms viz. (1) peeled and deveined (2) peeled deveined and cooked (3) cooked and peeled (4) Headless shell-on

(1) Peeled and deveined prawns:

The prawns are peeled, deveined, washed thoroughly in chlorinated water (5-10 ppm) and graded. The prawns are then arranged in trays each holding 2 or 2.7 kg. of prawn depending on the declared drained weight

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or they are arranged directly in waxed cartons lined inside with polythene. Ice water is poured in the trays or cartons and admitted into the freezer (contact plate or tunnel freezer) maintained at -40°C. The freezing will be complete within 2 to 2½ hours in the contact plate freezer (more time is required in tunnel freezers). In the case of prawns frozen in trays the slabs obtained are dipped in ice water for glazing. The glazed slabs are then wrapped in polythene and packed in waxed cartons. Ten such slabs are packed in master cartons made of corrugated paper board and stored at -23°C till shipped.

(2) Peeled, deveined and cooked

In this type the prawns (usually small size) are peeled, deveined, washed thoroughly, cooked in 3 to 5% brine (Nacl) for 3 - 5 minutes and cooled. The cooled prawns are filled in trays and frozen as above.

(3) Cooked and peeled

The prawns after washing are cooked in 7-10% boiling brine for 2-3 minutes depending on the size. The material is then immediately cooled in ice water containing 3-5% salt. Peeled and washed thogoughly in 20 ppm chlorinated water. The material is then filled in trays and frozen as usual.

(4) Headless shell-on

In this case only the heads are removed, but the shell is left on the prawns. Rest of the freezing procedure is the same as in the case of peeled and deveined prawns.

Individual quick freezing of prawns

In this case prawns (peeled and deveined) are quick frozen individually by using fluidised bed or by liquid nitrogen freezing systems. After freezing the IQF prawns are packed in moisture - vapour proof packagings and stored at -23°C.

Lobsters

The tails of lobsters are frozen for export. The head, vein etc. are removed from the lobster and wash thoroughly. Remove the eggs, hanging

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pieces of meat etc.. if any, from the beheaded and deveined material and again wash thoroughly. Grade the pieces for size and wrap the individual pieces in polythene paper. Quick frozen at -35 to 40°C. Pack the frozen material in 5 kg. or 10 kg. lots in dealwood containers lined inside with moisture-vapour proof paper and store at -23°C.

Lobsters are also frozen as whole in raw condition or after cooking in salt solution.

Crab:

Raw and cooked meat of crab are preserved by freezing. In fresh crabs the meat sticks to the shell very firmly and hence separation is difficult. However if the material is iced for 12-24 hours, the meat becomes loose and picking is easier. The picked meat is washed in water containing 10 ppm chlorine, drain and pack in polythene lined trays. Glaze water is added (about 50 ml/kg meat) and frozen at -40°C in the minimum possible time. Pack in moisture proof containers and store at -23°C.

The crab meat is also frozen in the cooked form. For this crabs are cooked in 3% brine (Nacl) for 15 minutes and the meat is separated and frozen as described above. The claw meat is also frozen in raw and cooked conditions.

Clams and mussels

Meat is separated from clams (villorita sp.) and mussels (Mytilus edulis) after cooking in steam for 15-20 minutes. The meat is washed thoroughly in chlorinated water, packed in trays, glaze water added and frozen at -40°C and stored. Clam quality deteriorates relatively fast upon freezing. They become tough and spongy with considerable loss of drip.

Freezing of squid and cuttle fish

Squid and cuttle fish are economically important invertibrate animals falling under cepheloped group. They are soft bodied marine animals with no external skeleton and with their feet around their mouth. Squids belong to the family loliginidae and cuttle fish sepidae.

Squids have cylindrically elongated body with an internal skeleton

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which is chitinous in nature and quite fragile. The internal skeleton is known as pen or gladius and is almost transparent. Cuttle fish are with flat body and having a pair of narrow fins. The distinctive internal skeleton known as cuttle bone is calcarius in nature.

Squid and cuttle fish are frozen mainly as whole or as tubes. Tubes are prepared by removal of head, viscera,ink sac, chitinous pen etc. without damaging or opening the mantle. Skin is removed from the mantle and the material is thoroughly washed in potable water. The fins are also removed and stored in ice water. From the ice water material is removed for packing and freezing within the shortest possible time. Freezing is done either individually or as blocks (2 Kg.)

In the case of whole frozen squids/cuttle fish the thoroughly cleaned whole material of highest quality are used. The common practice **is** to close the ink sac by tieing the opening with a piece of thread or closing the opening with a plastic clip. The material is then frozen as mentioned above.

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CANNING OF FISH AND SHELL FISH

B Y

K.K. Balachandran,
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INTRODUCTION:

Canning is that method of preservation of food where spoilage is averted by killing the microorganisms present by application of heat. Fresh foods, fish particularly, normally carry microorganisms which if not restricted in their activity, will cause spoilage. The basis of preservation by canning rests on the destruction of these microorganisms by heat and the prevention of entry of others from any external sources . Therefore canning can be called the process of heat processing of foods in hermetically sealed containers.

Since the publication of the invention of this process in 1810 by Nicholas Appert, 'Appertization' as canning was originally known, has underwent radical changes in all aspects except the fundamentals. Though comparatively a new process for preservation of foods it is estimated that today some 2500 different products are sold in cans. The advantages of preservation by canning compared with other methods are:

1. Storage at room temperature. Properly processed foods keep well for years.
2. They are cooked foods and are instantly available for consumption.
3. Food is protected against any sort of contamination, reinfection by outside microorganisms, and is inaccessible to insects and other pests and is immune to absorption of gases from atmosphere.
4. The process is applicable to a large variety of foods - of animal or vegetable origin.
5. The process renders itself readily for automation.

OUTLINE OF CANNING OPERATIONS

The important steps involved in canning operation are:

1. Selection and preparation of raw material
2. Pre cooking/blanching
3. Filling
4. Exhausting

5. Seaming
6. Heat processing/retorting
7. Cooling, drying, labelling, casing and warehousing

Broad outline of the operations involved remaining the same as above details of the process may differ according to the type of material used and the style in which the product is required by the consumer.

1. Selection and preparation of raw material.

Quality of any processed food will depend upon the quality of the raw material to start with. Since the thermal destruction of bacteria follows a logarithmic pattern, their presence in large numbers will necessitate longer time of heat processing for elimination. Therefore it is essential that the number of bacteria present in fish prior to canning be kept as low as possible. Great care has to be exercised in selecting only absolutely fresh fish for canning. The canning process also should be completed as quickly as possible.

Preparation of the fish will vary depending upon the type of fish used and the end product envisaged.

2. Blanching/pre-cooking

The prepared fish is subjected to this process before or after filling in cans. The prepared fish is immersed in cold or hot brine or hot water or is exposed to live steam with or without pressure for a predetermined period depending upon the material and type of pack. This will ensure sufficient shrinkage of the raw material to permit adequate filling in the can; impart firm texture to the meat, expel gases from the cellular tissues which will improve the final vacuum in the can, reduce the bacterial population and inhibit enzymic reactions. Brining will result in removal of slime, blood, some solubles and also gives necessary salty taste.

3. Filling

Blanched material is next filled in cans. Be it by hand or by mechanical means, it requires careful attention. The cans must be clean and correct weight must be filled in each can. Ratio of solid to liquid material will markedly influence the rate of heat penetration into the product which will affect the processing time. No air pocket should be

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left in the material which cannot be removed by subsequent exhausting. Overfilling may lead to seam strains during retorting and bulging at ends. Filling should be done so that, when cool, the surface of the contents is within 0.6 - 0.9 cm from the top of the can.

4. Exhausting

Exhausting aims at removal of air from can contents and head space before seaming. This achieves (1) minimisation of strain on the seams due to expansion of air during retorting (2) removal of oxygen which accelerates corrosion in the can and oxidation of foods, particularly fat (3) enabling a vacuum to be formed inside the can which ensure the ends remaining concave even when the storage temperatures are little higher than usual. Vacuum will also serve as a reservoir of hydrogen which may be formed by reaction between the can and its contents (4) reduction in the distinction of Vitamin C.

Exhausting is achieved by heating, mechanical vacuumisation or by steam injection to the head space. In heat exhausting the contents are heated immediately before filling in cans and quickly sealed or passed through a steam box so that the temperature at the centre of the can is 70°C. The cans have to be seamed immediately before they cool down. In mechanical exhausting a vacuum pump connected to the seaming machine sucks air from the can inside a chamber and the can is closed under vacuum. In the steam injection method steam displaces air from the head space of the can.

5. Seaming

Seaming has the objective of obtaining a tight seal between the cover and body of the container so that microorganisms are prevented from entry into the can after the cans are heat processed. This is usually achieved by the method of double seaming.

After seaming the cans are generally passed through a tank containing hot detergent, generally 1-1.5% solution of sodium phosphate followed by rinsing with hot water to remove the detergent residue which, otherwise, will cause can corrosion. This step is essential since, otherwise fish pieces, oil, sauce etc. adhering to the surface after seaming will contaminate the retorts, clog them, and even prevent the sticking of the labels to the cans after processing. This will further increase the liability of the outer surface for corrosion.

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6. Processing

Heat processing of fishery products is carried out in retorts using pressure steam. Cans are subjected to heat treatment at a pre determined temperature for a length of time sufficient to kill or inhibit organisms which may cause spoilage without overcooking the contents.

Though preservation of canned food is ensured by the destruction of bacteria present, complete sterility in the food is not aimed at nor is it desirable, since exposure of food to heat for an unduly long period enough to ensure complete destruction of bacteria may impair other qualities of food. What is aimed at is a 'statistical sterility' which means that no viable microorganisms can be detected when a sufficiently large number of cans are carefully examined from a given lot. It has been observed that spore forming or even asporogenous bacteria can be present in canned fish without causing any apparent spoilage. This state of 'dormancy' is often favoured by the presence of fat which encapsulates the bacteria and render it insensitive to heat as also inactivate it. So long as the product is in good condition and free of pathogens it can be considered hygienically acceptable. This particular state of affairs has led to the concept of 'commercial sterility' which implies that the food is free of pathogens and that under the given conditions of normal storage the food will remain in good condition for 2 years or more.

It is well-known that destruction of bacteria follows a definite pattern; the same proportion of surviving bacteria being destroyed in successive units of time. This means that higher the content of bacteria in a pack, the longer the time required to reduce their numbers. The temperatures below 60°C are not lethal for asporogenes and those below 100°C for spores. Time and temperature required for processing various packs have been determined experimentally and ensure that spores of the most heat-resistant food poisoning organism known, viz. Clostridium botulinum, are destroyed. There are other organisms whose spores are more resistant to heat and which, although will not cause food poisoning, may cause spoilage and for this minimum processing time is often exceeded when recommendations are made.

Processing time and temperature required for each food depend on (1) the type and number of spoilage agents present in the product, (2) the consistency of the product - solid packs and thick liquid requiring larger

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processing time, and (3) the acidity of the product. Most spoilage agents are less resistant to heat in the presence of acids and usually the more acid in the product, the less the processing time required.

Sterilizing action of steam depends upon the transfer of its latent heat of evaporization to the surface of the cans where it condenses. Dry or superheated steam condenses less readily and hence is less efficient.

Before developing the steam pressure it should be ensured that air has been completely expelled from the retort. This is very essential since (1) air reduces the retort temperature unevenly resulting in there being cold spots in the retorts and the consequent intermittent spoilage of cans, (2) a mixture of air and saturated steam at any temperature is not as efficient as saturated steam at the same temperature, and (3) air cuts down penetration of steam. Therefore it is of paramount importance that sole reliance on retort pressure alone should not be made, but should be checked with thermometer reading of temperature, and both should be checked periodically for accuracy.

In any type of heat penetration into the can there is some point which receive the heat only last. This point of slowest heating inside the can is called the 'cold point'. For solid or very viscous packs which heat mainly by conduction this point is generally taken as the geometric centre of the can. For products which heat mainly by convection this point has been located on the can axis at a point between the geometric centre and the bottom of the can and is about ½" to 2" from the bottom depending upon the type of the can. For mixed heating the 'cold point' can be at the geometric centre or near the bottom of the can axis. In thermal processing technique it is a pre requisite to know the exact location of the 'cold point' in the can so that the processing time and temperature can be so adjusted that the food at this point also receives sufficient heat treatment for ensuring the stability of the product without the food being subjected to unnecessary exposure to heat. The rate of heat penetration is generally measured by inserting thermocouples at cold point.

Canned foods heat either by conduction or convection or both. In heat penetration shape and size of the container are very important since the rate of heat penetration is affected by the ratio of the surface area

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of the container to its volume. Heat transfer is accomplished more quickly through metal than glass. Likewise, fill of the container and the size of the particles have an influence on the rate of heat penetration. The rate of heat transfer may be greatly accelerated by the use of agitating retorts.

7. Cooling, drying, labelling etc.

Rapid removal of heat from the processed cans is essential to prevent overcooking in the product. This will also inhibit the growth of any thermophillic bacteria that might have survived the processing. As a rule the cans should be cooled immediately to below 37°C so that sufficient heat will be retained to ensure drying of the can surface and thus protect against rusting.

During heat processing the pressure in the can increased due to expansion of contents. At the end of processing pressure inside is maximum but is partially balanced by the retort pressure. If the steam in the retort is dropped suddenly the can may be permanently distorted or the ends forced out to such an extent that severe strain on the seam results with consequent risk of spoilage.

Majority of can which slow spoilage become infected during cooling. Leakage may take place only at the moment when the seam in contact with cooling water changes its shape from convex (internal pressure) to concave (vacuum) condition and the degree of contamination is more with the extent of pollution of cooling water. Therefore, only chlorinated water (5 p.p.m) should be used for cooling. Continuous use of the same cooling water helps in building up bacterial load, particularly in later stages when there will be ample nutrients in the form of fish particles etc. washed off from can exterior.

Cooling is generally carried out by inserting the crates containing cans in cooling tanks outside or by pressure cooling inside the retort by spraying.

Canned products as a general rule are not shipped immediately. They should be kept cased for a minimum period of 1 - 3 months which will ensure proper distribution of salt, if added as such, oil, spices etc. This will also ensure a check on the sterility of the contents.

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The processed cans must not be cased hot because the loss of heat by radiation from the cases will become slow which will provide favourable condition for the development of thermophillic bacteria which might have survived processing. Cans should not be stored adjacent to steam pipes or left to freeze during storage. Warehouses should be clean, cool and dry. Water condensing on can surface, high humidity or temperature, corrosive fumes etc. leads to rusting of the can surface.

SPOILAGE IN CANNED PRODUCTS

There exists a basic difference in the concept of spoilage in canned products from that accounted for in other types of processed foods inasmuch as any defect in the container may be accounted for spoilage eventhough the contents may be perfectly normal. So also with material spoiled inside the container, but the cans may appear perfectly normal externally.

'Swell' or 'blower'

Normal cans have their ends either concave or flat. Cans with bulged ends due to positive internal pressure due to gas formation of gases as a result of microbial or chemical activity is called 'swell' or 'blower'. A hard swell' is one in which the ends are firmly and permanently extended. If the ends can be moved by thumb pressure, but cannot be forced back to the normal position it is called 'soft swell'. A can in which one end is bulged but can be forced back to the original position where upon the other end bulges is called 'springer'. A flipper is a can of normal appearance but on striking against a solid object one end 'flips' out and snaps back to the original position when very slight pressure is applied. 'Swelled' cans pass successively through the stages of 'flipper' and 'springer'.

The Chief causes of spoilage are:

A Microbial - 1. Under processing
2. Inadequate cooling
3. Infection resulting from leakage through seams
4. Pre process spoilage.

B. Chemical -- Hydrogen swell

C. Physical - 1. Faulty technique in retort operation
2. Under exhausting
3. Over filling
4. Panelling

D. Miscellaneous 1. Rust
2. Damage

(1) Underprocessing

A product which suffers spoilage as a result of the activities of the microbial organisms surviving heat processing can be termed underprocessed. In such packs the microbial activity may result in gas production causing 'swelling' or the contents may undergo acidification or other undesirable changes affecting quality without gas production. When microbial spoilage takes place without gas production the affected cans have a normal appearance, the spoilage being detectable only on opening the can.

In spoilage due to underprocessing, unless the pack is grossly underprocessed, it is generally observed that the spoilage is due to a single type of organism. In low or medium acid products this is usually a spore forming species. In bacteriological investigations on this type of spoilage the organism responsible or at least the group to which it belongs may be traced immediately in order to trace its origin. This should involve all-raw materials, plant,equipment etc.

Underprocessing may result from faulty operation or poor design of retort. Localised under heating due to presence of water or pockets of air in the retort affects a part of its load of cans which remain underprocessed. Underprocessing can occur when the cans are stacked without free access to steam or when solid filled is excessive.

(2) Inadequate cooling

Flat sour thermophiles multiply rapidly at 49 - 71 °C and, if the cans are not rapidly cooled below this temperature, will lead to serious spoilage. Cans are generally cooled to about 35°C, but if stacked immediately at this temperature in large blocks still stands the risk of flat sour

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spoilage. Cans, therefore, should be stored in relatively smaller stacks in a cool, well ventilated warehouse.

(3) Leakage through seams

Microorganisms infecting canned fish as a result of post process leakage of containers will be of widely varying types. The main souce of the organism is the cooling water. General experience shows that post process infection of cans result in the formation of 'swells' which indicates that the original leak becomes sealed by the can contents or that the defective seam has some valvular action. If the contaminating organisms are non gas producers the cans will remain normal in appearance, so also the cans will not swell if the seam defect is so severe to permit free passage of air.

In leaker spoilage though there may be more than one type of organism present, at times it may be contaminated by a single species. This may be the case where cans have been cooled in chlorinated water in which bacterial count will be reduced to resistant spore formers.

Very minute defects in seam, small enough not to permit the entry of bacteria, results in depreciation of vacuum until equilibrium with the atmosphere is attained. In such cases cans remain normal unless subjected to wide temperature fluctuations or to a change in altitude whereupon the ends may flip. Whereas in air tight cans oxygen may be absent or present in very small amounts, in such leaker cans it may be present in very high proportions. In plain cans such oxygen will be absorbed by metals in few days whereas in lacquered cans this absorption will be delayed by the lacquer film.

Leaker spoilage can be minimised by (i) making the can seams as near the ideal as possible (ii) maintaining the bacterial content of can cooling water at a low level (iii) carefully manipulating the retort during cooling process (iv) ensuring proper exhausting of cans thereby minimising seam strains.

(4) Pre process spoilage

This type of spoilage occurs where bacterial multiplication in the product is permitted during the preparation stage. Undue delay between filling and processing, particularly in products where some heat might have generated

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by cutting, milling etc.causes multiplication of the fast growing organisms. Processing may subsequently sterilize the pack, but liberation of gases produce by the organisms during the lag period may cause swelling or flipping of the can.

B. Chemical - hydrogen swell

Cans which bulge as a result of production of hydrogen due to internal corrosion of the can is known as 'Hydrogen swell'. Bulging may range from flipping to hard swell and corrosion may, in certain cases, result in actual perforation of the can. Hydrogen swells are associated chiefly with foods such as fruits containing organic acids and their formation will depend on (i) the efficiency of the exhaust, (ii) size of head space in the can, (iii) storage temperature etc. Examination of internal corrosion alone cannot give a reliable degree of hydrogen swell since as much corrosion can be observed in normal cans also. Analysis of head space gas is a reliable method where proportion of hydrogen should be at least half of the total volume of gases present.

C. Physical

1. Faulty retort operation:

Too rapid reduction of steam at the end of heat processing results in setting up of high pressure inside the cans. This may cause severe strains and distortion on the expansion rings of the can ends so that, when cooled, cans give the appearance of 'swells' which can, more or less, be forced back to the original position. Abnormal strain may lead to 'Peaking' or permanent deformation of the expansion rings on the can ends. Strain on the can ends should be eliminated as far as possible since it may be conducive to leaker spoilage. Less rapid reduction of steam pressure or pressure cooling should be resorted to.

2. Under exhausting

Under exhausted cans will suffer serious strain during heat processing due to the excessive internal pressure set up by the expansion of entrapped gases. Seriously under exhausted cans will appear from slight flipper to grossly distorted after processing depending upon the residual air and gases evolved from the material and the size of the head space.

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Even grossly distorted cans on cooling willshow only a slight internal pressure, but such cans are unmarketable. Moderately under exhausted cans which show low vacuum may not present serious container distortion during heat processing, but shipping such cans to hot climates or high altitudes will result in bulging due to high temperature or low atmospheric pressure. It is estimated that for every 1000' rise in altitude there occurs a loss of 1" in vacuum.

3. Over filling

Due to expansion of the contents over filled cans become strained during heat processing. Vacuum will be absent in such cans and may result in flipping or springing of the ends. Inefficiently heat exhausted cans overfilling is unlikely to occur since excess contents will overflow due to expansion. Overfilling is most likely to occur in vacuum closed or cold filled cans.

4. Panelling

Panelling occurs usually in large size cans in which there is a very high vacuum when the can body is forced inwards by atmospheric pressure. A similar effect is produced in pressure cooled cans where the air pressure is excessively high or can is made of thin tin plate. Panelled cans which are only moderately exhausted may become flippers since diminition in volume caused by partial collapse of tin cans decrease the volume further. Serious panelling may result in seam leakage, especially if the seam is of substandard quality.

D. Miscellaneous

1. Rust

Cans showing external rust formation require very careful consideration. After removal of the rust if the iron plate is found pitted it is advisable to classify such cans as spoiled since the danger of perforation is great.

Rust formation is minimised by application of lacquer externally; it is a must for cans intended for long storage or exposure to severe climatic conditions. Rust formation is particularly liable to occur under labels when

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the label or adhesive used contains hygroscopic substances. Exposure to humid atmosphere accelerates rust formation. Excessive cooling after processing also may give rise to rusting.

2. Damage

Damage can occur due to rough handling of cans. The extent and location of damage are significant. Marked deformation of the seam will attract the risk of leakage. Severe dents on the can body causing seam distortion should be rejected.

APPLICATION OF CANNING TECHNIQUES IN THE CASE OF INDIVIDUAL FISHERY PRODUCTS

The types of fish and shell fish which are amenable to preservation by canning are several. Eventhough the general principles outlined above are applicable to all these, variations occur in the finer details when the technique is extended for canning the individual fish of shell fish.

Indian fish canning industry which grew substantially in the early sixties was practically only a prawn canning industry which owing to several reasons showed a marked ebb in the succeeding years. Whereas canning and marketing of prawn has become not a viable one there exists several other commodities which, if properly exploited and processed in the way desired by the consuming public, are likely to have tremendous market possibilities. Mackerel, sardine, tuna, seer, cat fish, lactarius, anchoviella, crabs, clams, mussels, oysters etc. are few which offer tremendous potentialities for the upkeep of the canning industry. Brief mention will be made of the methods likely to yield good results when canning of some of these commodities are attempted.

One of the simplest of the canning procedures employed commercially is canning salmon 'natural style' where the cleaned pieces of fish is packed with little powdered salt and heat processed after exhausting and double seaming. The fish retains all the natural qualities originally present.

Oil sardine is a fish which if freshly utilised, has been found to be quite amenable to packing 'natural style'. However, in order to impart desirable qualities to the fish and the self juice generated in the can, it has been recommended that the fish after nobbing and sealing be

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dipped in a solution of 15% sodium chloride containing 1% each of citric acid and potash alum. The treated fish can be directly packed in can, exhausted, seamed and heat processed. Container best suitable for packing sardine 'natural style' is the quarter dingly can.

For packing sardine in oil, sauce or other media, the process of brining followed by packing in cans, precooking in steam, draining of the drip (alternately, cook with cans kept in an inverted position), pouring in hot oil (or other media), exhausting, seaming followed by heat processing can be adopted.

Mackerel, if very fresh, also can be packed 'natural style'. If not the procedure adopted for sardine can be adopted for mackerel also. Lactarius, anchoveilla, pomfret etc. are other fishes which can be canned almost in the style detailed for mackerel or sardine.

There occurs some variation in the process when fish like tuna, seer etc. are canned. Tuna (skipjack, albacore, yellow-fin, blue-fin, big-eye) are generally headed and gutted and then cooked in steam by keeping in racks in single layers until the temperature at the central bone reaches around 90°C. After cooking the fish is kept in cold room overnight when the muscle becomes firm facilitating easy handling. The cooled meat is cleaned of the skin, the bone and the red meat found around the backbone region. The white meat loins are cut into the size of the can, packed in can, powdered salt is added to give salty taste, filling medium addeed and proceeded as in other cases.

In the case of bivalves like clams and mussels, the live animals are allowed to starve overnight by keeping them in water collected from their natural habitat, followed by a treatment with chlorine when due to the irritation caused by chlorine and the consequent convulsive movement of the body most of the sand content from the stomach is expelled. They are then steamed and the meat is 'shucked' out. The meat is then given a further blanching in brine and then processed as usual. The carapace is first removed from the crab, cleaned of all coloured juices and the carcass is split into two and then kept in running water for a sufficiently long time to bleed. The carcasses are then cooked in 5% brine, the meat separated in the form of flakes, packed in parchment-lined cans and filled with dilute brine, exhausted, seamed and processed. Addition of 0.05% EDTA to the filling brine is advised as a check against any discoloration that may take place.

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SOME PROBLEMS ENCOUNTERED IN CANNED FISHERY PRODUCTS

1. Struvite formation

'Struvite' crystals, a colourless, tasteless, odourless, transparen and harmless chemical substance of the formula $MgNH_4 PO_4 6H_2O$ is found associated with canned crab, prawn or tuna particularly when such cans are stored at cold temperatures. Use of hard water in product preparation or use of stale material for processing or very slow cooling of the processed cans have been traced as the cause for occurrence of this phenomenon.

2. Sulfide blackening.

Trimethyl amine oxide (TMAO) present in marine fish dissolves the tin layer of the container. The exposed iron will react with sulfur containing constituents of fish meat producing iron sulfide. Use of a sulfur resistant protective lacquer on the tin plate can take care of this problem.

3. Curds and adhesion

This phenomenon occurs due to the precipitation of protein. Use of raw material of which the freshness is lost, improper brining and precooking are some of the causes for the occurrence of this phenomenon.

4. Blue discoloration

Copper in the haemocyanin of crab meat combines with sulfur to produce copper sulfide which has been traced to be the reason behind this phenomenon. Thorough bleeding of crab meat, maintenance of proper acidity, using a parchment lining preventing the meat in coming into contact with any exposed iron (to prevent blackening) use of a chelating agent in brine etc. are suggested to overcome this.

5. Retort burn

This phenomenon is usually met with canned shell fishes like clam, mussel or oyster where due to inadequacy of the filling medium employed the solid food at the top is left 'dry'. Use of sufficient medium to cover the solid is the remedy.

CONTAINERS FOR CANNED FOODS

Since the method invented by Nicholas Appert for preserving food by heating it in glass bottles after sealing carefully with cork a thorough revolution has taken place in the development of container. The'hole and cap' metal containers used in earlier days have been obsolete and 'sanitary' or 'open top' cans have largely replaced any other container. They have a cylindrical body with soldered lock seam outside and unsoldered double seam ends. 'Qr. dingly', 'club' or 'oval' cans are drawn cans or two piece cans.

Normally cans are made out of tin plate which makes use of cold reduced base steel plates over which a coating of tin, either by hot dipping or electrodeposition, is provided. Tin plate has the general composition 98% steel and 2% tin coating. The maximum limits of impurities permitted in steel plate are C. 0.05 - 0.1%, Mn. 0.3 - 0.5%, P. 0.015% max; S.0.03%, Cu.0.06%, Si 0.01%.

Aluminium cans with 'lift tab' or 'Pull tab' lid have already became very popular. It is highly advantageous for the consumer since it is very easy to open the can using the 'lift tab' arrangement which pulls off the lid along the scoring.

Container is an important item which increases the cost of canned food. Attempts are going on in developing cheap and efficient containers of canned foods and notable achievements in the field are the development of flexible aluminium pouches lined with polypropylene or disposable heat sterilizable plastic containers, both of which are becoming increasingly popular.

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DEHYDRATION OF FISH AND FISHERY PRODUCTS

by

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Sun drying of fish has been a traditional process of fish preservation in most of the countries of the world. Inspite of the development of most sophisticated process of fish preservation such as canning and freezing, sun drying retains its significance in fish processing industry. Large quantities of fish are being sun dried in various countries for human consumption. The process, however, is inordinately slow and gives a product lower in nutritional value and high percentage of moisture which decreases its storage life. The product may also get contaminated with pathogenic bacteria due to the attack of flied & insects and often get mixed with sand and dirt. Moreover, sun drying is entirely dependent on weather conditions.

In our country it has been estimated that about 40% of fish landing still preserved by either sundrying or salt curing and drying or converted into fish meal. A major part of dried fish so produced is consumed internally and a part is exported to countries like Ceylon, Burma, Singapore, Arabian Countries and African Countries. Our dried products fail to confirm to the quality specification of Western Countries mainly due to the fact that our fish drying industry is not modernised. It has been observed that better quality product can be produced under controlled conditions of air in artificial driers called as dehydrated fish. Dehydration is complex and expensive process but dehydrated fish has more monetary value than sun dried one.

Compared to other methods of fish preservation, dehydrated food is more concentrated, require minimum equipment, less costly and product can be stored and distributed at much reduced cost.

The first attempt on artificial dehydration of fish was made in Canada. In our country, Central Institute of Fisheries Technology, Cochin has developed different types of mechanical driers for drying various types of fish and fishery products. In this paper, an attempt is made to illustrate the technical aspect of different types of driers and processes used in fish processing industry.

Mechanical driers used for dehydration of fish and fishery products are broadly divided into three catagories: Hot air drier, rotary drier and vacuum drier.

Hot air drier

This is the most important group of driers widely used for fish dehydration. The basic principle of drying is the removal of moisture by evaporation from fish muscles by application of heat and subsequent removal of evaporated moisture from its surrounding. In hot air drier air is heated by steam or electric heater which is blown over the fish surface by an air blower and the evaporated moisture is carried away by the same air. The moisture carrying capacity is more if the air is hot and dry (low Humidity) and is moved at faster rate. If the three parameter (temperature, humidity & air velocity) are properly controlled, quality product can be produced in quickest possible time.

i) Cabinet Drier

The first development of hot air drier is cabinet or chamber drier. It essentially consists of a rectangular wooden or asbestos cabinet in which trays of fish is placed on shelves which may be fixed on the chamber or on movable trolleys. Air is blown by a fan past a heater (steam or electric) across the fish. It is usually the least expensive, easy to maintain and flexible in operation. The main draw back of this type is non-uniform drying.

Tunnel Drier

It is basically a cabinet type batch drier operated in a programmed series as semi-continuous manner. This type of drier is most commonly used for dehydration of fish in mass scale.

A laboratory model tunnel drier designed by this Institute consists of a long wooden cabinet divided into upper and lower chamber by a partition wall. In the upper chamber electric heater of suitable capacity is fitted and in this air is blown by an air blower fitted at one end at high velocity across the heater. Hot air is forced down by an air reflector which turns the air to the lower chamber. In the lower chamber fish is kept on aluminium trays supported on shelves in several layers to the chamber wall. Hot air after passing over wet fish gets wet and therefore, a part of this air is removed by an air exhaust fan and the rest is recirculated along with fresh air in order to get the desired humidity. The temperature and humidity are controlled by electronic instruments.

Drying of fish and meat (protein food) in an artificial drier is very complicated due to the fact that during drying protein undergoes lot of changes rendering the product as hard mass unless it is dried at controlled air conditions. From the laboratory studies, it has been estimated that most of the fishes like Mackerel, white Baits, Lactarius, Killimean, Shark etc. can be dried successfully at an optimum air temperature and humidity of 45-50°C and 55-65% RH respectively and an average air velocity of 100-120 m/mt. and takes about 14-16 hrs. to dry a batch of fish.

Based on this laboratory model, the Institute has designed a commercial drier of one tonne capacity. It consists of a long concrete tunnel divided into upper and lower chamber. In the upper chamber, two steam heaters. one air blower, several instruments for controlling air temperature and humidity are fitted and in the lower chamber, five trolleys of mild steel construction are moved on rails. On the trolleys several layers of aluminium fish trays are arranged in the form of shelves. Production is so scheduled that when trolley of finished product is moved out from one end of the tunnel, a trolley of fresh fish is put in the line. Air is moved counter current (opposit) to the direction of trolley movement for maximum efficiency, rate and quality of product.

Multi-deck Tunnel Drier

This is the most recent concept in tunnel drier design. In place of a tunnel, several such are placed one above the other and air is blown in a zigzag fashion three ~~before~~ times before it is exhausted. All the controls, heaters, air blower and exhaust fan are placed on the sides. Laboratory model fabricated by the Institute consists of three decks and fish trays are moved manually. One of the problem of tunnel drier design is the length and it is difficult to control air conditions particularly air flow. But in multi-deck drier, better control and more thermal efficiency can be achieved. By moving the fish from one deck to the other mechanically, it is possible to design a continuous drier for fish and fishery products using multi-deck principle.

iv) Fluidised Bed Drier/Through Flow Conveyor Drier

This is another recent development in hot air drying. When air is passed over a bed of solid, air flows between and around the particle without disturbing them but as the pressure is gradually increased a stage is reached when the air pressure lifts the bed and entire bed is suspended in a condition of constant agitation"(boiling)" and as such solid particles can be blown to any place like a fluid. In this case, drying takes place in quickest possible time. This is used for drying fish granules like fishmeal, fish powder type of fishery products. In case of fish which is difficult to suspend in air, fish is put on a wire mesh conveyor belt which is moved inside a tunnel drier and hot air is passed through the fish. These type of driers have got high thermal efficiency.

Process of Production of Dehydratedm Fish

For drying of fish in hot air drier, the raw material is first washed to remove dirt, slime and cut open from dorsal side, intestine and gills are removed and again washed well to remove dirt, blood and slime. This fish is directly put on trays into any one of the driers descrobed here but in most cases salting of fish is practiced. Fish after dressing is salted in 1:4 or 1:5 (salt:fish) ratio for 18-24 hours. After salting the fish is lightly washed with water to remove excess salt and dried in the drier with flesh side up. Air conditions are properly controlled to the optimum level to get a quality product having good reconstitutional properties. In case of big fishes like Shark, the flesh is first cut in the form of fillets which are then salted and dried. Small fishes like Sprats and Whit Baits are dried as such without salting while Bombay Duck are dried by hanging on ropes in a current of hot air to a certain moisture level, then it is laminated and dried on trays. In case of prawns which is a major dry fish industry is dried by cooking the meat in brine for 15-20 minutes and then drying on trays in mechanical drier. It is very important to note that for most of the fishes except prawn, care should be taken to see that the meat does not get cooked during drying due to heat of high temperature air. Generally, unsalted fish and prawns are dried to 10-15% moisture level and salted fish to 25-30% moisture level in the product. Properly dried and packed product can be stored for 3-6 months depending on storage conditions.

Rotary drier

All types of rotary driers consists of cylindrical shell mounted horizontally or at slight angle on rollers or bearing so that it can be rotated by a suitable drive mechanism. The source of heat is generally air which circulates through the shell or it can be supplied from the steam heated jacket. This type of driers are generally used for fish meal production.

i) Rotary Drum Drier

The Institute has developed a rotary drum drier for the production of fish meal and prawn pulp. It is a batch drier with steam jacket and is made out of mild steel The drum is mounted on ball bearings and is rotated at 15-20 r.p.m. The internal baffles lifts the materials and the evolved moisture vapour is drawn out by an exhaust fan. [illegible] the evolved moisture vapour [illegible]. The material to be dried is charged inside the drier, the drum is rotated while drying and steam is passed inside the jacket. For the production of prawn pulp, the whole prawn as such or after beheading is charged in the drier and the drier is operated as per instruction when the product gets dried, and deshelled in one operation within 4-6 hours. Based on this the Institute has designed a half ton drier.

ii) Direct Rotary Drier/Flame drier

This type of drier is widely used all over the world for the contineous production of fish meal. It consists of a long steel, shell having length about

10 times the diameter (length depends on the drying time of material) of the shell is set with its axis slightly inclined to the horizon and is mounted on rollers. This is rotated at slow speed (1-3 r.p.m) by a drive mechanism. Material to be dried is fed at the high end of the drier which travels towards the low and due to the rotation and slope of the drier assisted by the longitudinal, flights fixed inside the shell. The material comes in direct contact with the hot air passing through the shell counter current to the flow of material and intimate mixing of material with the hot air takes place due to the agitation of material by the bafflos. High temperature air is generally used in this type of drier by direct burning of any convenient fuel at the low end and in such case it is called as 'flame drier'. Disadvantage of so called flame drier is the contamination and charing of fishmeal by the products of combustion (flue gas) of the fuel. So, in modern design, air is heated by passing it through a bunch of finned tube steam heater at the low end or products of combustion of fuel heats the finned tube heater in place of steam. In this drier, the dried product is continuously collected from the low end by suitable mechanism as shown. A part of dry fish meal is carried away by the drying air which is collected by a dust collector (Cyclone).

iii) Indirect or steam tube drier

This is more or less the same except the heating arrangement. Here, heat is supplied by steam jacket along the entire length of shell or a row of steam tubes is fitted inside the full length of the shell. This has got the advantage of more heat transfer than the jacketed one. As the material cant come in contact with the products of combustion, this type of drier gives a better quality product. In some design both these principles are combined. In fishmeal manufacture generally two driers are used in series depending on the moisture content of feed. This type of rotary continuous fishmeal drier are already in operation in the fish meal plant at Malpe (Karnataka), Azhikode and Calicut (Kerala), Zafrabad (Gujarat) and Mandapam (Tamilnadu).

Manufacture of fish meal

Fish meal is a valuable feeding stuff with high content of digestable protein vitamins and minerals for our domestic animals and poultry. Fish meal is manufactured from lean miscellaneous fish which do not find any ready market, fish waste such as offals, trimings etc. from fish processing factories and press cake from fish body oil extraction plants. Trawlers operating along our coast bring substantial quantity of miscellaneous fish.

In CIFT designed rotary drum drier, fish meal can be produced by simply charging the drier with lean fish or in case of fatty fish, after cooking and pressing, the pressed cake is charged and the drier is operated for 6-8 hours. Dried product is discharged by rotating the drum, the meal is pulverised and bagged. The Whole meal method, ie. without cooking and pressing is more advantageous due to saving of labour charges, more yield and less loss of nutrients with the press liquor and better appearance.

In continuous fish meal plant of very high capacity of 1000 to 1500 tons of raw material/day, the process is somewhat different. Raw material is first disintrigeted, cooked in a continuous cooker, pressed in continuous screw press to produce press cake which is again disintegrated and charged continuously at the high end of the flame drier where it is partly dried (say) 30-40% moisture level. At this stage, it is mixed with concentrated spent liquor recovered from screw press and passed through another indirect drier. In this way high quality whole meal is produced without involving much technical difficulty in drying. In some plant, fish meal is produced without admixture of spent liquor due to economy. Fish meal is generally dried to a moisture content of 8-10%, packed in gunny bag and stored.

Vacuum drier

This is a class of drier where the removal of moisture takes place by application of low temperature and vacuum and the evolved vapour is traped in a condenser. Heat is applied by conduction or radiation. In many cases particularly fish or other delicate food material it is desirable to dry at low temperature and without contact with oxygen (air) and in such cases vacuum driers are used. It gives better quality products but cost is higher compared to other class.

i) Vacuum Shelf Drier

It consists of C.I. or M.s. rectangular or cylindrical insulated shell inside of which hollow shelves are fitted. These shelves are fitted with hot water / steam or hot oil heating arrangement. Material to be dried is spread on trays which are placed on these shelves. The Chamber is connected to vacuum pump via a condenser. After charging the material the door is closed, vacuum is applied, and steam/hot oil is passed at desired temperature inside the shelves which gradually heats up the material and water vapour is evolved at the existing vacuum of the chamber which is 25-28" of mercury generally. The material is removed after breaking the vacuum.

ii) Freeze Drier

This is a modification of vacuum shelf drier. By using high vacuum (below 4.7 mm. Hg. and 32°F), it is possible to establish specific conditions of temperature and pressure whereby the physical state of food substances can be maintained at critical point for successful dehydration with marked improvement in quality. Under these circumstances water molucles pass from solid phase to vapour phase directly with out passing through liquid phase. The constructional details are more or less the same as described under vacuum shelf drier except that high vacuum vessel and low temperature condenser using refrigeration are used. Heating may be done by radiation or conduction method.

Freeze dried products have natural colour, flavour, rapid and complete rehydration potential, retains original shape and contains most of the nutrients of the original raw material and have good storage life at ordinary temperature but is highly costly process. Ready to serve prepared food can be well preserved by this method for defence personnel and are now widely used in space flights. This type of food can be consumed by simply mixing with require quantity of hot or cold water. Freeze drying is perhaps the ultimate answer in dehydration. Several types of freeze driers have been developed from time to time, each differing mainly in their heating arrangement of which accelerated freeze drier available in this Institute is most dfficient. A commercial freeze drier is in operation under Defence Ministry at Tundla near Agra.

iii) Vacuum Double Drum Drier

This type of drier essentially consists of two metallic rolls of stainless steel having smoth surfaces placed in contact and are rotated towards each other at slow speed by a suitable drive mechanism. These drums are housed inside a vacuum chamber and steam is passed inside these drums through rotary joints. Generally this type of driers is used for drying fishery products in the form of solutions like fish solubles, peptone, fish soup mix etc. Semi liquid material is fed in the V shaped space between the rolls and as the drums rotate, a coating of material is automatically applied on them thickness of which depends on the clearance between the drums. A scraper blade (called Doctor knife) removes the dried material from the surface before the drum starts next rotation. Dried material may be collected on trays inside the chamber or conveyed by suitable conveyor. There are several modifications to this type of drier. Some times it is operated at atmospheric pressure. There may be single, double or triple drums and feeding may be done by spraying on the drum or by immersing the drum in a pool of liquid. In more sophisticated model the product is removed without breaking the vacuum.

iv) Rotocone Vacuum Drier

This is a double cone shaped vessel having a small cylindrical portion and is mounted perpendicular to the axis of this compound vessel on hollow shafts as shown. The vessel is fitted with two doors, steam jacket, vacuum and steam connections through this hollow shafts via rotary pressure joints and is rotated by suitable drive mechanism at medium speed. This is mainly used for final drying and mixing of fish powder like F.P.C.(fish protein concentrate and fish meal (edible) with other stachy ingradients. This drier has got the advantage of vacuum drying while the material is in a state of agitation.

Process of production of vacuum dried fish

Pretreatment of vacuum drying of fish is the same as described under hot air drying except that salting is never done in this case. Generally, final moisture is kept below 5%.

In case of freeze drying, the thickness of raw material should not be more than 1cm. After dressing and washing the raw material, it is spread on trays in single layer and the material is frozen in a quick freezer, the frozen fish is inserted in the drier and drier is operated as per operational instruction. Particular attention is paid to see that the material does not get melted during drying. The material temperature is kept below -20°C and vacuum below 1mm. Hg. Generally, it takes about 8-10 hrs to dry to 1-2% moisture level in the product. Vacuum in the chamber is broken by admitting inert gas (nitrogen) In case of pre-cooked food, the procedure is same. Sometimes, if it is not possible to freeze fish in a freezer, the same can be frozen in the freeze drier itself by evaporative freezing method.

In vacuum double drum drier, the feed must be a thick liquid having about 50% solid. Feeding is done from outside tank at a controlled rate of flow in such a way that no excess material is fed. The feed is sucked inside by the vacuum. Dried material is obtained in the form of sheet or flakes which can be powdered if necessary.

In rotocone drier, material can be handled in semi-dried powdered form to remove last traces of moisture. This is also useful for mixing two or three powdered material.

However, all these artificial driers referred to here require capital investment and the cost of running them also to be worked out to be very high. Hence, it is felt that if all the disadvantages of sun drying are removed, sun drying can be the ideal, cheap and practical method of fish preservation very much suiting to the fishing villages of our country. Moreover because of threat of recent energy crisis all over the world, it is felt necessary to use solar energy for fish dehydration.

Solar drier

In CIFT, a solar drier has been developed which utilizes solar energy for drying of fish under hygienic conditions. A mechanism has been developed whereby the heat is absorbed from the Solar radiation for heating air. The fish to be dried is enclosed in a chamber of hot air out of contact with contaminating agents responsible for the deterioration of sun dried products. It has been observed that the dried product prepared in this solar drier is as good as that obtained in tunnel drier in quality but the cost is comparatively very low.

Dehydration is one of the easy way of preservation of food which a common man can easily adopt. There are several types of mechanical driers for different types of fish and fishery products. Now it is up to the user to adopt a suitable drier for drying fishery products.

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CURING OF FISH

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INTRODUCTION

Curing comprises of the traditional methods of preserving fish by drying, salting and smoking. These were evolved to provide food reserves in places and at times when fresh fish was not available. They are all relatively simple and cheap methods and were first developed before recorded history began. When the technological aspects of freezing and canning were unknown and yet to be developed, dried, salted and smoked fish served the demand for cheap protein food of excellent keeping quality. In a developing country like ours these process have a great significance and relevance being very simple and cheap requiring least technical expertise. In most of the developed nations of Europe and Japan also cured products of great variety are being manufactured and relished by millions of people.

Micro-organisms must have moisture in their environment for growth and multiplication. Fish spoilage bacteria require an environment containing at least 50% moisture for normal growth. Some species of bacteria are killed by drying while others go into a dormant condition and will only start multiplying again if more water becomes available. This accounts for the keeping properties of all dried foods. The simplest method of preservation in temperate and tropical climates is to hang it up in the air when water slowly evaporates from it until equilibrium is reached.

Salting is in effect an extension of drying. Salt has a mild bactericidal effect, but its main value as a fish preservative is that it withdraws water from the bacterial environment. Theoretically, other soluble substances like sugar could be used in place of salt as it was done some time in the past.

Smoking has been in practice among several societies especially in Europe, side by side with salting and drying. Smoke contains bactericidal substances which are deposited on the fish in relatively large amounts. The keeping qualities of smoked products therefore arise partly from the properties of smoke itself and partly from salting and drying.

SALTING

a) Theoretical aspects:

Salting with or without subsequent drying is the most important method of fish curing. It is both a method of preserving fish and a preliminary operation to smoking, drying and marinading. The preservative action of common salt is its ability to exert a high osmotic pressure, giving rise to reduction of moisture content of the flesh and plasmolysis in the bacterial cells as a consequence. Apart from this, most of the enzymes are alsc destroyed or made inactive by the concentrated salt solution formed thereby preventing autolytic decomposition.

The presence of 4% or more salt in solution in the tissue of flesh retards both autolytic and bacterial decomposition and if the amount of salt in solution in the flesh is 20% or more, the decompositi8n processes proceed very slowly, only prolonged storage at high temperatures brings about noticeable spoilage.

With reference to the reaction towards common salt, bacteria could be divided into three groups.

i) Halophobic or Salt-sensitive ,

They include most of the pathogens and prtrefactive types. e.g. Pseudomonas and Achromobacter spp. These organisms cannot grow in salt concentrations higher than 6%.

ii) Halotolerant:

They consist of spore-formers, micrococci, and some anaeroboes, particularly clostridium botulinum. They can grow in concentrations higher than 6% and even upto saturation, although the rate of growth decreases with the increasing concentration of salt.

iii) Halophilic:

These are salt-loving organisms which grow best in the presence of salt. Practically, the halophiles fail to grow in the absence of salt and the optimum growth occurs in salt concentration higher than 2%. Bacteria causing 'red' or 'pink' in salted fish are the most important members of group. These are aerobes with optimum temperature ranging 15 - 55°C. Most of them fail to grow below 10°C. They are not pathogenic.

b) Quality of salt and its effect on the product

Based on the origin, common salt may be either solar salt manufactured by the evaporation of sea water or rock salt mined from underground deposits. Salt to be used for curing should not contain impurities insoluble in water as this lower the sodium chloride content in a given weight of salt and also will leave a crust of impurities on the product making it unattractive. Solar salts usually contain relatively higher amounts of Calcium and magnesium in the form of chlorides and sulphates when compared to rock salt. Calcium and magnesium ions affect the colour, texture and taste of the product to a great extent. Fish salted with pure salt are soft and flabby with very light yellow or cream colour. Such fish when reconstituted and cooked closely resemble fresh fish, they posses few of the qualities usually attributed to salted fish. The presence of as small a quantity as 1% of Ca^{++} and Mg^{++} together in salt causes remarkable whitening and stiffening of flesh. Salts of both these metals impart a strong bitter taste to salted fish. It has been shown that the rate of penetration of salt is not practically altered in the presence of Ca^{++} and Mg^{++}. These impurities lower the equilibrium moisture content corresponding to different relative humidities, thus affecting the packaging characteristics and shelf life. Besides chlorides of these bivalent metals make the common salt hygroscopic.

From the bacteriological point of view, most of the solar salts have been shown to contain a sizeable population of halophilic bacteria in them. Consequently, the products prepared out of these salts will have every chance to get affected with 'red' or 'pink'.

The ISI has formulated standards of quality for the common salt to be used for curing fish.(I.S.594 - 1962).

c) Salting Methods: Before processing, fish is normally dressed. Usually, the gills and entrails are removed, the fish is split open along the vertibral column. In the case of big fishes, scoring at several places or filleting is resorted to. When the fish is very small the whole fish is used. e.g. sundried Bombay duck, sole fish or ribbon fish.

Usually, the dressed fish is kept intimately mixed with salt crystals (kench cure and pickle cure) or by immersing them in salt solution (brining). In kench cure, fish is salted in piles consisting of dressed fish and salt placed in alternate layers allowing the self brine to drain off. In pickle cure, fish is treated with dry salt in water tight containers and the self brine is retained. In brining the dressed fish is kept in brine of desired concentration for the required time. This is usually done as a preliminary step before drying, smoking and canning.

In some cases, mixed salting is carried out. e.g. herrings. They are first mixed with dry salt followed by complete covering with brine. The advantage of mixed salting over dry salting is that fish are completely surrounded and immersed in brine straightaway thereby quickening the process. This is particularly valuable with large or fatty fish. The natural self brine is slow to form and the top layers get salted only after brine has filled all the interspaces between fish in lower layers.

MARINADING

The development of putrefactive micro-organisms is greatly delayed in an acid medium with a vinegar concentration of 1-2% with a higher concentration of acid a number of bacteria perish. On the contrary, some organisms like moulds and yeasts will thrive in an acid medium. Moulds gradually decompose the acetic acid and thereby create favourable conditions for the development of putrefactive bacteria. Acetic acid stimulates the bacteriostatic and bactericidal action of salt while salt stimulates the action of acetic acid. Thus both are mutually complementary in combination. For example, yeasts develop very readily in an acid medium, but stop growing at a 14% salt concentration and pH 2.5. An equivalent effect in a neutral medium is reached only at a salt concentration of 20%.

For marinading fish are kept in solutions containing 6 to 18% salt and 0.3 - 4% solution of acetic acid. The taste and consistency of the fish depends on the vinegar which dissolves calcium phosphates and thereby helps to soften the bones. Fish used for marinading include herrings, white fish, sardines etc. These are the main types of fish which undergoes maturation on salting. Marinades could be prepared from both fresh fish and salted fish.

TYPES OF SALT CURED FISH:

Based on the quantity of salt utilised for processing, salted fish could be divided into three categories as s- (1) light salted (2) medium salted and (3) Heavy salted.

A cure may be saturated or unsaturated depending on the amount of salt. Usually, the amount of salt used must be sufficient for the water inside the fish to be saturated with salt at the end of the process. This implies that about 36 kg. of salt are required for every 100 kg. of water in the fish. For example, if the fish contains 75% moisture, then about 27-28 grams of salt will be required to make 100 grams of fish saturated with salt. If a smaller amount is used, the cure is termed unsaturated.

For obtaining light salted products curing is done by applying 16-20 parts of salt to 100 parts of fish (by weight). The resultant product contains 20 - 30% salt on dry weight basis. In the case of medium salting, 20 - 28 parts of salt per 100 parts of fish (by weight) are used. The product will be having a salt content of 30-40% on dry weight basis. For heavy salted fish, 28-34 parts of salt per 100 parts of fish (by weight) are used and the product will contain 40 - 45% of salt on dry weight basis.

In the case of light salted fish, the period of salting should hot be more than 24 hours, otherwise putrefactive changes begin to take place during the salting stage itself. Drying also will have to be done quickly to ward off the chance of infestation by maggots, etc. Brown discolouration and rancidity due to fat oxidation and other putrefactive changes would be quicker and more pronounced in light salted products. If proper preservatives are used light salted fish products also will remain good condition for fairly long periods. Alternatively, the moisture level will have to brought down to 30% or less for reasonable shelf life.

In the preparation of heavy salted fish, the salting time will be usually above 24 hours.

DRYING METHODS

Either natural method of drying by solar evaporation or drying in an artificial drier could be resorted to. In tropical countries like ours solar energy can very well be utilized with great economic advantage.

PACKAGING AND STORAGE OF DRIED FISH

Naturally or mechanically dried fish could be packed in sacks in batches of say 50 kg., either loose or tied together in bundles. They can also be packed in boxes, cartons or baskets or even dry barrels. Bamboo baskets or polythene lined gunny bags also can be used. Dried fish should be stored in cool dry well ventilated premises.

SPOILAGE IN SALTED FISH

(i) **Rust:**

It is a common type of spoilage in salted fish products giving them an unpleasant taste and rancid fat odour. The surface acquires the colour of rusted iron. The reason for this is the oxidation of fat due to contact with atmospheric oxygen. The tissues of live fish contain natural antioxidants protecting the fat. Soon after the death of the fish these disintegrate and moreover salt acts as a catalyst and accelerates the oxidation process. The first stage in fat oxidation consists in the formation of peroxides which cannot be detected organoleptically, since the appearance, taste and odour of the fish remain unchanged.

Peroxides are later converted into other oxidation products by a chain reaction to aldehydes, ketones, and hydroxy acids. These end products are responsible for the rancid odours and brown discolouration. It has been observed that even traces of Cu^{++} ions in curing salt catalyses the oxidation reaction considerably.

The best method of controlling the oxidation process is by preventing contact with air as much as possible. Fish should be kept covered with brine during salting and storage and dry fish properly packed and pressed down in the container. Packing in hermitically sealed and exhausted high density polymer films(polythene or cellophane) could be used advantageously.

(ii) 'Pink' or 'Red':

It is another common form of spoilage in salted fish particularly in warm weather. The surface of the fish becomes covered with a red slime that gives off an unpleasant smell. It is brought about by halophilic rods and cocci originating from the salt used for curing. Almost all solar salts have been seen to harbour a sizeable population of halophilic bacteria. e.g. Serratea salinaria, Serratia cutirubra, Sarcina littoralis, Micrococcus roseus. These organisms being aerobic develop only when the fish is in contact with air and if the temperature is fairly high. The optimum temperature has been shown to be around 36°C. These will not develop at all below 10°C. When the slime first appears it is easily washed ~~and~~ off and the fish is edible since these organisms do not evolve toxins. But the 'red' is likely to appear fairly soon, so that fish affected should be dealt with promptly. When the fish strongly affected the surfaces soften due to protein decomposition and it gives off the odour of ammonia. The flesh acquires an alkaline reaction and becomes inedible.

Preventive measures consist in keeping the fish out of contact with air and storing at lower temperature. Several chemical preservatives have been tried. One of the successful chemical method of preventing the onset of 'red' is by treatment with sodium propionate at 3% level. It is equally effective against mould attack also commonly met with in dry fish. The preservative is best applied by dipping the dressed fish in a 3% acquous solution of sodium propionate for 15 minutes followed by the usual method of salting etc.

(iii) Maggot infestation:

Salted fish is frequently infested by the larvae of the cheese fly (Drosophila casei) which is much smaller than the house fly and more elengated in shape. The cheese fly deposits its eggs on the salted fish or on the sides of the container. Its total cycle of development is about a month. The cheese fly thrives in warmth and multiplies freely above 20°C. Maggots hatch in two to four days and after two days begin jumping, spreading rapidly, soon infesting the whole salted fish. The maggot metamorphoses into a red pupa from which a fully grown cheese fly emerges a week later.

The best preventive measures are to keep the premises clean, to have concrete floors and to ensure that fish are well convered when being salted so that no fly can lay eggs on them.

(iv) Mould:

Salted and dry fish products are usually attacked by moulds. Bacteria and yeasts stop multiplying when moisture is less than 25% and for moulds the limit is 15% or less. Using some fungistats the mould attack could be effectively prevented. e.g. Treatment with sodium propionate in the same concentration as in the case of prevention of red halophilic bacteria will be quite sufficient.

CURED FISH PRODUCTS OF COMMERCE IN OUR COUNTRY

(i) Sun-dried fish:

In some parts of Maharashtra, especially in places north of Bombay fishes like bombay duck, eels etc. are usually sun-dried. Other important varieties which are also sun-dried elsewhere include ribbon fish, sole, white bait and shrimp. Bombay duck is dried on tenters. Others are normally spread on open beach exposed to sunlight.

(ii) Dry salted fish:

Dry salting is the most common type of cure and is practised widely. Ratio of fish to salt varies from place to place depending upon the size and fat content of the fish.

e.g. 1 : 4, 1:5 and 1:6 for large fishes and 1 : 8, 1:9 or 1 : 10 for small fishes. Period of salting varies from 18 hours to several days. Fishes like mackerel, sardine lactarius, otolithus, silver bellies, perches, jew fish, shark, cat fish, pomfrets, and seer are cured by this method. Dry salted fish is later dried in the sun.

(iii) Wet cured fish:

It is also known as the Ratnagiri method in Bombay area. The salt is applied in three instalments, half of the earmarked quantity is rubbed to the cut surface of fish stacked on cemented floor at the beginning and the other half in two instalments during the two subsequent days. Self brine is allowed to drain off. In Kerala area, the salt is applied in one instalment. Mackerel, sardine and small sized cat fish are processed by this method. The product is marketed without further drying.

(iv) Pit cured products

Pit curing process is similar to wet curing described earlier with the difference that the fish treated with the requisite quantity of salt are buried in pits lined with cudjan mattings over the sides, top and bottom. It is then covered with sand and trampled down to exert pressure. After two to three days in the pit, fish is removed and marketed without any further processing.

(v) Colombo cured products:

This method had been in vogue in S.Kanara and Malabar areas. It is essentially a pickling process. The material produced by this method was intended mainly for export to Ceylon. Usually mackerel and sardine were used for this type of curing. The dressed fish is salted in the ratio 1:3 or 1:4, a small quantity of 'goruka puli' (Malabar tamarind - Garcinia cambogea) is placed in the belly cavity of the fish. This fish is arranged in large barrels with intermittent layers of salt and 'goruka puli'. About 50 grams of 'puli' are required for every 1 kg. of fish. The pH of the self brine will be around 5.

(vi) Semi-dried Prawns and Prawn Pulp

To prepare prawn pulp, prawns are boiled in 5% brine or even in sea water and sun-dried on coir mattings or bamboo trays. Hard dried stuff is put in gunny bags and beaten to separate shell from meat.

The method of preparing semi-dried prawns consists in blanching cleaned prawns in 5 - 7% brine for about 5 minutes, shells are removed by hand. The meat is again put in saturated brine for a few minutes and dried to a moisture level of about 35%.

QUALITY STANDARDS FOR CURED PRODUCTS

Cured products vary widely in quality especially in the moisture and salt levels. Infestation by fungus, red halophilic bacteria, maggots and insects is quite common. Salt used by the curers also vary in chemical composition and does not conform to the standards set for the purpose.

ISI has laid down quality standards for several cured fish products. Export Inspection Agency has also formulated standards for products meant for export. These are no statutory standards for products inte for internal sale, which form the lion's share.

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PRESENT STATUS OF THE FISH CURING INDUSTRY IN INDIA

At present nearly 20% of our fish catch is processed by traditional methods. But technologically, the curing industry has not registered any marked progress even after several decades. It is essentially the same age-old process. Although great advances or breakthroughs in many other aspects of fish processing like freezing, canning or dehydration have taken place, improvements have always eluded curing industry in India. Japan utilises about 40% of its landing for the production of cured products. In European countries also, products based on salted herrings, etc. are produced on modern lines. Since the curing process are comparatively cheap, a developing nation like India can very well rely on them for producing cheap protein food from the sea. Thus cured fish products could aspire to cater to the protein needs of a large number of our population.

SUGGESTIONS FOR IMPROVEMENT OF FISH CURING INDUSTRY

Some suggestions that may help to build a base for the development of curing industry are noted below:

1. Complete and economically viable schemes for the production of cured fish on modern lines have to be drawn up.

2. One or more model fish curing centres based on the above scheme should be started and operated in each State either under the Government - State or Centre - or in the Co-operative Sector. These model production centres should have a training and demonstration programme for the benifit of private curers and entrepreneurs.

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3. The products prepared on scientific lines at the model processing centres should be sold in retail on a no-profit-no-loss basis to make the improved products popular and to tfansfer the fruits of technological advances eventually to the common man.

4. Government will have to help private curers who generally come from the weeker sections of our society in setting up new production centres with model layouts, supply of potable water, curing salt of requisite quality, packaging materials, preservative chemicals if any, etc. Some of the materials may have to supplied at a subsidised rate if required. The Government can also help them in the successful marketing of their products.

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SMOKE CURING OF FISH

By

T.S. Unnikrishnan Nair,
CIFT, COCHIN-29

INTRODUCTION:

Smoking is one of the major methods of processing fish. Nearly 2% of the world's fish catch is used for preparing smoked products. Smoked fish is a delicacy, ready-to-eat and as such have a great demand in sophisticated markets of the West. Besides, smoking is employed as an intermediate step in the manufacture of canned smoked fish.

Broadly, there are two methods of smoking: (1) Hot and (2) Cold. The flesh of hot smoked fish is delicate, succulent and tasty but the product has only limited storage life. Hence, hot smoked fish products are manufactured at plants in big cities with sufficient demand to facilitate immediate marketing. Cold smoked fish is more stable and are noted for their pleasant odour.

Apart from these two important processes, two more methods of recent origin are also being practised on a limited scale. They are: (1) Electrostatic smoking wherein the period of the process of drying, smoking and baking of small sized fish is reduced to 12 - 18 minutes. This is achieved by means of high voltage current of the order of 40,000 volts or above, and infrared heating. (2) More recently, another method of combined smoking has been developed. Here, the fish are first treated in a smoke fluid and later smoked in the usual kiln. By the preliminary smoke treatment, 15-30% of processing time could be saved.

THEORETICAL CONSIDERATIONS

(a) FUEL

The only suitable fuel is wood-saw dust, shavings or logs. It is used both as a source of heat and of smoke. During the smoke curing process, smoke imparts a specific aroma and flavour as well as an

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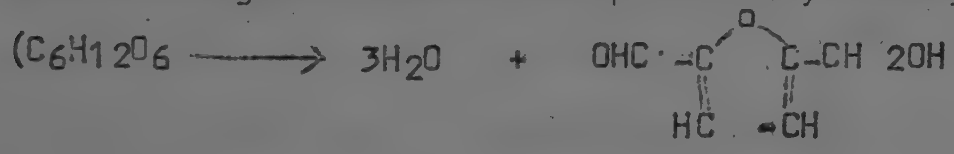
attractive golden yellow colour to the product. It is also an effective carrier of heat and moisture. Any wood, which is likely to give the fish an unpleasant odour or taste, is unsuitable. The best woods for smoking are : alder, birch, oak, poplar and beech. Usually woods with less resinous matter are favoured.

Wood consists of combustible and non-combustible substances. The non-combustible materials are moisture and ash. The combustible substances are complex organic compounds, viz; cellulose, lignin, hemicelluloses, tannic acids, protein substances, resins and terpenes.

Cellulose is the cellular fibre that constitutes the bulk of wood. It consists of polysaccharide $(C_6H_{10}O_5)n$ with the approximate molecular weight of 1,500,000. Cellulose on high temperature hydrolyses to simple monosaccharides, mainly glucose, $(C_6H_{10}O_5)n + nH_2O \quad n(C_6H_{12}O_6)$ which undergoes further decomposition yielding oxy methyl furfural,



$$(C_6H_{12}O_6 \longrightarrow 3H_2O + \underset{HC=CH}{OHC-C\overset{O}{\frown}C-CH_2OH}$$

which being unstable breaks up yielding formic acid $HCOOH$, levulinic acid $CH_3COCH_2CH_2COOH$ and humic substances which help to give smoked fish its characteristic colouration.

Lignin is part of the wood cell walls and contains the methoxyl group CH_3O - which as a result of hydrolysis gives methanol.

$$R-O-CH_3 + H-OH \longrightarrow R-OH + CH_3OH.$$

Lignin is more resistant to heat and begins to dissociate at 350°C other products from lignin pyrolysis are tar, methyl ester of pyrogallol and its homologues and dihydric phenol esters. The composition of the tar has been known to be guaiacol, vinyl guaiacol, cresol, catechol, phenol and eugenol.

Hemicelluloses consist of pentosans $(C_5H_8O_4)n$ and hexosans

$(C_6H_{10}O_5)n$. On hydrolysis, these polysacharides form pentoses and hexoses.

Protein substances are present in a larger proportion in hard woods than in soft woods.

The smoke formed by the dry distillation of wood consists of gaseous and liquid distillation products of organic compounds. Their out put is high varying between 80 - 87% of the organic matter present in the fuel depending upon the type of wood. When the temperature of wood is raised from 100°C to 150°C much water vapour is released yielding only 2% volatile matter. When the temperature is raised to 200°C, it chars, the output of volatiles being 25%. Upto 280°C, heat has to be applied externally in some way. With still further heating the nature of pyrolsis changes, the release of volatile matter increasing appreciably and combustion is accompanied by the generation of heat. At about 300°C, wood catches fire.

When the combustion is incomplete, the smoke generated contains organic substances which can impart a smoky flavour to the fish. If the combustion is too intense and complete, these organic substances break down to the end products of CO_2 and H_2O and the smoke essential for curing will not be available. A good quantity of smoke could be obtained by burning saw dust. When saw dust is burnt, the supply of air to the hearth is restricted, the fuel burns slowly and incompletely and so much smoke is produced.

(b) NATURE AND CHEMICAL COMPOSITION OF SMOKE

Smoke is a typical aerosol. The solid particles and liquid particles are dispersed in a gaseous medium. The gas dispersing medium consists of O_2, H_2, N_2, CO_2, CO and various hydrocarbons. The dispersed phase contains a number of chemical substances of diverse composition.

During smoke curing of fish, the largest concentration of smoke is at the top of the kiln. More tarry substances will settle on fish in the upper part of the kiln than in the lower part.

The chemical composition of smoke is complex and has not yet ty. been fully studied. With incomplete combustion, some of the wo as in the case of dry distillation. Consequently four groups

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are yielded: (1) gases (2) aqueous distillate (3) tar distillate and (4) carbon.

Gases consists of mainly CO_2, CO and hydrocarbons. The following compounds are usually found in the aqueous distillate:

(a) acids and their derivatives - formic, acetic, propionic, butyric, valeric, isocaproic and their methyl esters.

(b) alcohols - methyl, ethyl, propyl, allyl, isoamyl and isobutyl.

(c) aldehydes - formaldehyde, acetaldehyde, furfural, methyl furfural and 2-methyl furane

(d) Ketones - acetone, methyl ethyl ketone, methyl propyl ketone and ethyl propyl ketone.

(e) hydrocarbons - xylene, cumene and cymene

(f) phenols - catechol

(g) pyridine and methyl pyridine.

Tar distillate contains both low and high density tar oils. Low density tar oils have a boiling point below 140°C and contain:

(a) Valeric aldehyde.
(b) furanes - furane, methyl furane, dimethyl furane and trimethyl furane.

High density tar oils are heavier than water with a boiling point above 200°C. They contain : (a) phenols and their derivatives - phenol, O-,m-, and p-cresols, xylenols, ethyl phenol, catechol, guaiacol, esters of pyrogallol and (b) lignoceric acid.

The aromatic substances in the tar are products of lignin decomposition.

(c) BACTERICIDAL PROPERTY OF SMOKE

Pure cultures of non-spore bearing organisms like putrefactive bacterium proteus vulgaris or staphylococci will be destroyed by smoke, after exposure for three hours, whereas pure cultures of spore bearing [illegible] will survive. The spores of Bacillus subtilis and Bacillus mesentricus

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survive even when exposed to thick smoke for seven hours. The bacterial effect of smoke is due to the presence of formaldehyde, organic acids, phenols and other organic compounds which form the tarry distillate. Smoke with a temperature below 40°C has only a limited bactericidal action. By hot smoking, the number of microorganisms is considerably reduced which is due to the high temperature of smoke.

(d) SIGNIFICANCE OF PHENOLS IN SMOKED FISH

The characteristic colour, taste and odour of smoked fish owe to the products of dry distillation absorbed by the fish, especially the phenolic compounds. One of the main indices of the efficacy of smoking operation is the amount of phenols in the finished product.

HOT SMOKING

(a) Kilns:

Fish may be smoked either in batch kilns or continuous kilns.

Batch kilns

They are of two types (i) Chamber kilns in which the fish are loaded and unloaded at one end. (ii) tunnel kilns where the fish are loaded and unloaded at opposite ends.

(i) Chamber kilns.

The smaller types of chamber kilns are cabinets with the dimensions:

Length : 1.8 m.
Breadth : 1.3 m.
Height : 2.2 m.

Fish are loaded on racks in four to six tiers. Larger type of chamber kilns have the area of 2.5m x 4m. and a height of 2.3 m. The fish are charged manually on poles and the fires are lit on the floor of the kiln. In recent designs, the fish are loaded into the smoke house in cages along a monorail. The fuel is burnt on trolleys which move through the smoke house on rail and since the rails are laid in two tiers it is possible to heat the fish evenly throughout.

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(ii) Tunnel kilns:

The tunnels are approximately 3 m. long and 1.0 to 1.3 m. wide. Fish are charged in cages. The fuel is burnt either directly inside the kiln on movable trolleys or on external hearths near to the tunnel. Smoke is admitted from the hearth to the lower part of the chamber through openings all along the tunnel. Intensity of smoke and temperature are controlled.

Continuous or mechanical kilns.

A typical mechanical kiln has the following dimensions:

Length of the tunnel : 11.65 m.
Breadth " : 1.22 m.
Height " : 2.78 m.

The chamber has a metal frame structure and brick walls and can hold a number of fish cages. The movements inside the tunnel are controlled mechanically. There are controls for smoke intensity and temperature.

Torry kiln

The smoke kiln designed and developed by the Torry Research Station, Aberdeen is popularly known as the 'Torry kiln'. It is widely used in the U.K. for the manufacture of smoked fish. (Fig.).

(b) The smoking process:

Fish used for hot smoking must be of good quality. It can be fresh, chilled or frozen. The sequence of operation is as follows:

defrosting ⟶ washing ⟶ dressing ⟶ washing ⟶
salting ⟶ rinsing (draining) ⟶ binding ⟶
drying ⟶ cooking ⟶ smoking ⟶ cooling ⟶
grading ⟶ packing.

Dressing:

Small sized fish are smoked whole. Large fish are gibbed, headed
it into fillets.

sh are salted either by mixing them with solid salt or by brining in the requisite ratio. After salting, the fish are rinsed in fresh water or drained as the case may be.

Binding:

Large fish are tied with twine and the same may be fixed by skewers. Smaller fish are sewn through.

Loading:

The fish should not be allowed to touch one another. They are usually arranged in cages in two or three tiers.

Drying, Cooking and smoking:

Fish are fried and cooked before they are smoked. In the case of a mechanical continuous kiln the normal schedule of operation is as follows:

DRYING C

	Drying	Cooking	Smoking
Temperature (°C)	85-95	140-150	95-100
Time (min.)	20	25	20

Packing:

The smoked product is removed from the kiln and cooled. The quicker the cooling, the lower the infection by microorganisms. The cooled fish are taken from the racks, graded for size and quality and packed in cartons.

COLD SMOKING

(a) Preparation of Fish:

(i) Grading, Dressing and Salting:

Fish intended for cold smoking are first salted after dressing and preliminary grading for size and quality. This is essential for marketing of products of uniform quality, especially of definite moisture content and saltiness.

(ii) Soaking:

The saltiness of fish for cold smoking should not exceed 12%. If the fish have not been soaked long enough, the product will be too salty.

At the same time, if they are soaked too long, they will swell with belly softening. Salted fish is soaked usually by suspending in fresh water.

(iii) Threading and Binding:.

Fish may be threaded on spits, hung from hooks on poles or tied.

(iv) Drying before smoking:

After smoking, the fish flesh is very moist. It is later dried in open air or in an artificial drier.

(v) Smoking chambers and smoke generators:

Smoking chambers and smoke generators of different designs are being used.

(vi) Smoking process:

In the initial stage, when the fish is moist and the smoke has a high degree of relative humidity, the temperature inside the chamber should not be raised, to the maximum value. In the second stage, when the fish is considerably dry on the surface, the temperature in the chamber could be raised to a level tolerated by the particular fish. During smoking fish dries and absorbs the aromatic substances from the smoke. When the relative humidity of the smoke is above 75 - 80%, drying is quite slow. The highest output of good quality products is obtained when temperature, relative humidity and quantity of ventilated smoke are present in the correct proportion. The maximum temperature of cold smoke usually used is 40°C. The smoking time generally extends to several hours (36 - 72 hours).

ELECTROSTATIC SMOKING

In this process, fish are dried, smoked and then cooked. Smoking takes place as a result of the electrokinetic properties of smoke in a high voltage field of the order of 40,000 Volts or more. The process in principle is similar to electrophoresis. The baking is done by infrared heating. Smoking is provided from smoke generators. Advantages of this method are : Smoking process takes only 1/8th to 1/10th of the normal time;

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production losses are reduced and the output of smoked fish increased because of the shorter period of exposure to heat, the process is carried out in a mechanical continuous equipment.

SMOKING FLUIDS

In some plants, fish are smoked by a combination of methods. Fish are first immersed in an aqueous solution of smoke fluid for a few seconds before being smoked for 12 - 16 hours in a mixture of smoke and air. This process cuts the smoking time, increases productivity, reduces losses and gives a considerable saving in materials and out lay. However, organoleptic tests have indicated that fish smoked in this manner are inferior to those smoked in the conventional way.

PROSPECTS OF FISH SMOKING IN INDIA

Smoking of fish and meat for the purpose of preservation as well as for the particular smoke flavour has been carried out by some tribal sects on a very limited scale in our country from time immemorial. But no fish smoking industry as such has not been existing here. The smoke flavour is alien to the large majority of our people; the taste will have to be cultivated afresh. This could be done by distributing sample products of smoked fish among the people and making it popular. These products could then be marketed first in urban areas and later in rural areas. Published data show that a number of delicacies could be manufactured from different fishes available in India. We might also be in a position to export selected varieties of smoked fish to the Western markets. Hot smoking is best suited for our conditions and could be developed to a great extent.

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FISH CURING - IMPACT OF TECHNOLOGY ON RURAL DEVELOPMENT

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INTRODUCTION

Fish has already established a paramount position in human nutrition. This dietry status of fish is mainly attributable to its high protein content which is well known for its high digestibility. In addition, the low cholestrol level lipids, some of the essential vitamins and mineral matter present in fish substantially raises its status in human dietery. Besides, fish protein happens to be relatively very cheap and easily available even for the lower strata of society. In spite of all these plus points this food item has the greatest drawback in its short shelf-life and high perishability. Unlike most other agricultural commodities, fish deteriorates at a very rapid rate. Once the fish ~~i~~s spoiled it not only becomes most unpalatable but it can even form a health hazard. Our tropical climatic conditions virtually abets and accentuates this process of deterioration~~x~~. Various preservative methods are adopted to control or contain fish spoilage factors. Most common among these preservative techniques are icing or chilling, freezing, canning, dehydrating and curing, which generally encompasses techniques like smoking, picking, marinading, salting and and drying etc.

Brief History of Fish Curing

Among the various fish preservative techniques refered above, preservation of fish by the methods of curing is perhaps the oldest technique ever practised by fishing trade. It dates back to prehistoric days of storeage. The evidence of fish drying is available even in the Magdeleman period. Preservation by salting is of a later origin and can be related to the period of bronzeage. The ancient Egyptions extensively practised salting of fish. In Mesopotemia fish was salted, smoked and dried as early as 3500 BC. Salted and dried fish later became a major commercial commodity for the international barter trade. This method came down to Indus : valley civilization from Arabian countries.

Status of fish curing Industry

Prior to the advent of freezing and canning, fish curing was a major industry the world over. Subsequently its importance has considerably declined. It has now established itself and continues to occupy an important position even in developed countries. As per the FAO year book 1973 the total world fish catch is assessed as 65.7 million metric tons. Of these 71.8% is used for human consumption. 30.6% is consumed fresh, 18.3% is frozen, 12.3% cured and 10.6% canned. Out of 27.1 million tons of fish used for processing 30% is processed by curing alone. If we examine the position in some of the developed countries we find that Japan diverts 46.9% of its total catches to curing where as in canada it is 12% and Norway it is 11%. These data amply signifies the importance of fish curing at international level.

In India the status of fish curing is still more significant. In 1958, 50% of the total landing is processed by curing alone. By 1965 it came down to 25% and by 1970 onwards it has stabilized itself to a figure of 20%. Among the various fish processing methods fish curing alone handles 75.77%, freezing 21.05% and canning 3% of the total quantity fish subjected to processing. Of course compared to 1958 there has been a drop from 50% to the present level of 20%. This decline is not actually due to challenge from other processing techniques which is almost insignificant compared to curing in terms of quantity of fish utilized.

The fall in curing is mostly brought about by the increase in fresh fish consumption rate from 42.7% in 1958 to 65.30% in 1973. The development of better road communicati8n system in the coastal areas is the main reason for this increased consumption of fresh fish.

From the data presented here, it may be clear that inspite of the sophisticated methods like, freezing and canning, fish curing is still playing a very important role in the fishery economics and rural development of India. Freezing and Canning are highly capital Intensive, often needing import of costly equipment and machinery from abroad. These methods also needs high technical expertise and their production is almost exclusively intended for export market and doesnot in any way help to overcome the National protein difficiency of our country. These are some of the serious limitations. However the position of fish curing industry is entirely different. It is essentially a labour intensive industry needing very little technical expertise and financial outlay. As it is, fishcuring is an extensive small scale industry among the innumerable fishing villages scattered along the entire coast line of India. It is life and sustanance to innumerable illiterate fisher folk along the entire coast. The needs of this industry in the form equipments, technical expertise and financial outlay etc. being very meagre and also became of labour absorbable capacity, fish curing industfy has got to play a very decisive role in our rural development schemes. However it is true and pathetic that the present condition of our fish curing industry is most deplorable. This industry has never received any attention from our intelligentia. It is one of the most neglected fields of our fishing industry.

Some of the salient features of fish curing method which eminently gives a high status in our rural development schemes are summarised.

1. Doesnot require elaborate equipments and capital unlike other methods.
2. Methods are simple and even our illiterate fishermen can easily adopt them.
3. Unlike other sophisticated methods, any type of fish can be used for curing and can be carried out at any location, with improvised equipments.
4. The labour intensiveness of the industry will be a real boon to Indian conditions.
5. The cost of finished product is very reasonable.
6. The finished product has reasonable shelf life.
7. No special storage facilities are required.
8. Nutritionally cured products are good.

Different curing methods currently practised in India

1) Sun drying
2) Dry curing
3) Mona curing
4) Wet curing
5) Pit curing
6) Colombo curing
7) Somke curing

1) Sun drying

Generally small and thin types of fishes like white bait, silver belly, ribbon fish, soles, jew fish Bombay duck etc. are cured by sun drying. The idea is that the fish must get adquately dehydrated in the shortest time possible, before the tissue start deteriorating. No salt is used at all. The fish is just washed and straight away spread out in the open sun, either on mats, hard ground or even on sandy beach. Drying by hanging on ropes is very effective as in the case of Bombay duck. In beach dried products there will be often too much of sand. This process is extremely simple and cheap. Roughly about three days drying will be required depending upon ambient conditions. From the nutritional point of view the sun-dried products has an advantage in that at no stage nutrients are lost by salt leaching as in other curing methods. However too much of sand is a serious handicap. If properly dried and stored the sundried product has shelf-life of about 2 to 3 months and gives an approximate yield of 25% (Approximate).

2. Dry curing

In this case the fish are generally split open, vicera etc removed, washed and are then intimately roused in specific proportion of good salt. The salt proportion varies according to the size of the fish the season and fat content of the fish. After salting, the fish is neatly stacked in tanks or other receptacles with copious supply of extra salt on top. By osmotic activity salt penetrates into the fish tissues and in turn it expresses out water from the fish which accumulates in the tank as self brine, and engulf the fish. Usually heavy weights are placed on top of the fish stack to hasten the extraction of water. During this stage the fish muscle changes from translucent to opaque stage, looses stickness and becomes more fibrous in texture. This is called the struck through stage. The fish is allowed in this condition for one or more days, when the proper ripening or maturation takes place. After this the fish is taken out rinsed in water and then dried in the sun for 2 to 3 days. In rainy season if the drying conditions are not favourable, it is allowed in the tank till drying condition are favourable. Drying is done on mats or by hanging on ropes. After drying it is packed and despatched to market.

Yield - 48%, Shelf life = 90 days (Approximate)

Mona Cure:

This method is followed mostly in Maharashtra region in the case of mackerels, lactarius, Otolithus etc. The method is almost identical to dry curing, excepting that the fish is never split open. The viscera is very deftly removed by pulling it out through the buccal cavity. It is then washed and salt in the ratio 1:4 is stuffed into the belly cavity through the mouth and then stacked. After two days the salted fish is dried as in the case of dry cure. The product looks elegant and whole.

Yield - 70% shelf life 50 days (approximate)

Wet Curing

Some times called Ratnagiri method (kharavani) is almost skin to kench cure of western countries. In this case fish is split and gutted and then salted in 1:4 or 1:3 ratio and stacked in cement tanks or platform. Some weight is applied on top and the self-brine is allowed to drain out into the gutter. There is no drying at all in this method hence called wet cure. After 3 days the fish is marketed. The moisture content is as high as 50%. The salt content is also high (24.30% MFB) and this gives the fish the required protection. The shelf life of the product is very low - only about 2 to 3 weeks. In some areas of Kerala fish after salting is straight away stacked in bamboo baskets where the self brine flows out by itself. After the cure is completed the basket as such is sent to the markets for disposal.

Yield - 70.4% Shelf life two to three weeks (approximate)

Pit cure:

Pit cure is confined to certain areas of Madras State only. In this case fish is split and gutted and salted in 1:3 or 1:4 ratio and is then stacked in 2' deep pit in the sand lined with palmyraha leaf mats. When the pit is ¾ full it is covered over on the top by another mat and then sand. The maturation is strictly under anaerobic conditions for about 36 or 48 hours. The fish is then dugout of the pit and straight away marketed without any drying. The product is very unwholesome. The moisture content and salt content are very high as in the case of wet cured products.

Yield - 69.4% and shelf life about 20 days (approximate)

Colombo Cure:-

This is perhaps the only type of commercial pickling in India - carried out mostly in South Kanara and Malabar region. It is almost solely intended for Colombo market and probably hence the name. The fish usually mackerel is gutted and split. Mixed with 1:3 salt and a small piece of Malabar tamrind (Garcinea Cambogea) (1:10 ratio) and is then very neatly and tightly packed in huge wooden drums. Selfbrine is fully retained in the drum. The packing is very tight. The top lid is then fixed in a water tight conditions. The bung hole of the drum is opened and extra quantity of self brine or saturated brine is poured into the drum till it is completely full to the brim. This replaces all air pockets inside the drum. Now the bung hole is finally closed and the drum as such is exported to Ceylon. In this case also there is no drying at all. But the fish is in a medium of concentrated brine fortified by a small quantity of tamrind which gives a particular flavour and added protection. The fish is also out of contact with air and spoilage due to rancidity is also appreciably reduced.

Yield - 75.2% shelf life more than 6 months (approximately)

Smoke curing:

Though smoke curing yields very tasty products its life is very short unless stored in refrigerated conditions. Smoke curing is not widely practised in India. There are very large number of smoking procedures giving a variety of products. But the general principles are that big fishes are fully split, gutted, scored and washed. They are then immersed in brine for specified period. Fish is then taken out, Throughly drained and surface dried in the sun. The fish are then removed to smoke kiln and hung there. Smoke generated by burning saw dust, wood shavings, coconut husk etc. are let in and the temperature are raised according to the type of smoking - cold smoking or hot smoking. Smoking period is also variable according to the particular type. (about 16 hours, a temp. 50°C to 60°C). The fish are then removed packed and stored.

Yield about 40.8% shelf life about 40 days under ambient temp. conditions depending upon the type of smoking (approximate).

Though there are highly sophisticated smoke kilns like Tory Kiln, the cost is very high, for Indian conditions. Cheaper smoke kilns can be easily fabricated in India which will serve quite well for commercial purposes.

Packaging of cured products:

The packaging of cured products is really a difficult problem. Traditional methods used are, palmyraha or coconut plam leaf mats, gunny bags, bamboo baskets, wooden boxes, etc. None of them are air tight packages. Studies have revealed that the moisture content of the cured product goes down from the initial of 47% to about 21% in a period of 4 months, under ambient conditions. Of course this is depending upon the temp. and humidity conditions of the storage. But loss in weight is very substantial and adversely affects the trade. A polythene lining to these traditional containers substantially brings down this weight loss. But this brings in another problem. When polythene packed, the humidity level inside the bundle goes up very high which forms a very favourable medium for microbial spoilage like the reddening and fungus attack. This can be warded off only by using some efficient preservatives which will be discussed later. But we have to devise a very attractive packing system like carboard cartons for cured products so that it could be appealing to the higher strata of people also.

Spoilage in cured fish:

In spite of the preservative steps like salting, drying, smoking etc. cured products still undergo a gradual deteriorative change due to various causative factors. They are:-

1) Microbial spoilage

Though the high salt level and low moisture content are inimical to microbes, we cannot impose these two factors too rigorously lest it might effect tasting and reconstitutional properties of the products. They may adversely affect yield also. As such we may have to adopt some via media standards without sacrificing the organoleptic qualities of the finished product. Secondly some of these spoilage microbes have developed high resistive power against high salt content. This applies to both bacteria as well as molds. Take for example the well known halophiles and halotolerant bacteria as well as molds. Their origin is itself traced to impure solar salt which are widly used for curing industry. These organisms actually want a high salt concentration for their survival. Naturally spoilage in cured fish are bound to come unless some other protective measures are taken. These halophillic bacteria causes a deep red dis-colouration on the product.

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ENGINEERING ASPECTS INVOLVED IN FISH PROCESSING TECHNOLOGY

By

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CIFT, COCHIN- 29.

Fish, after catch, will have to be processed immediately in order to avoid spoilage during the subsequent storage. The usual practices of processing are:

- i) Chilling with ice or Refrigerated Sea water for short duration of storage
- ii) Freezing and then storing in cold storage for longer periods of storage
- iii) Canning
- iv) Drying
- v) Curing etc.

In order to process the fish in all of the above methods there are various machineries and equipments used for various operations.

As other authors are describing in detail the machineries used for canning, drying and curing processes and as there are more of machineries involved in freezing and frozen storage and Refrigerated Sea water plant, more emphasis is given in this article on those machineries.

Before going into the details of machineries let us go through the principles of refrigeration which is the basic cycle of operation irrespective of their operational variations.

Refrigeration simply means the removal of heat from air, water, brine or whatever substance it is desired to cool, and its transfer to another substance. If a cooling medium is available at a low temperature say ice, the operation can take place automatically by virtue of the natural tendency of heat to flow from a higher to a lower temperature level, but when it is necessary to transfer heat from a comparatively cold substance to a warmer one, special methods, involving the expenditure of energy have to be adopted. It is in this special sense that the term refrigeration is generally used.

MEASUREMENT OF HEAT:-

The unit of heat quantity most usually employed in British unit is the British Thermal Unit (BTU) and the Corresponding Unit in Metric

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system is Kilogram-caloric (Kg-Cal)

1 Kg-Cal = 3.97 BTU.

TON REFRIGERATION:-

In refrigeration work, two further units may be met with, these are, in USA and British Practice., the Ton Refrigeration and on the continent the FRIGORIE. The ton refrigeration is a rate of absorption of heat, and is equivalent to a refrigeration capacity of 12000 BTU/hr. Due to the fact that refrigeration was first produced by ice, the rate of removal of heat in a cooling operation was expressed in terms of pounds or tons of ice required per unit time, usually per day. It is seen that one pound of ice absorbs 144 BTU when it melts. Consequently 1 ton of ice absorbs 2000x144=288000 BTU when 1 ton of ice melts in 24 hrs. Hence the rate is $\frac{288000}{24} = 12000$ BTU/hr.

The FRIGORIE is simply a kilo-caloric and the term is used in expressing a refrigeration load or the capacity of a refrigerating plant.

VAPOUR COMPRESSION REFRIGERATION SYSTEM

This is the usual system adopted in all the Refrigeration machineries used in freezing and frozen storage of fishery products.

This system depends on two fundamental facts viz. (i) The large capacity for absorbing heat which a liquid possesses i.e. the latent heat necessary to transfer the liquid into a vapour (ii) The relationship between the pressure and the temperature of a saturated vapour.

Refrigeration is accomplished by the evaporation of a liquid refrigerant thereby extracting heat from the medium to be cooled. The refrigeration cycle is composed chiefly of four further steps, whose purpose is to remove this heat from the evaporating refrigerant by again putting it in the liquid state in order that it may be used repeatedly in a continuous process. To do this it is necessary that the gas be compressed, thereby permitting condensation at the normal temperatures of available water or air. This is done by compressors requiring mechanical energy. In order to understand the operation of the cycle, please refer to (Fig.1.).

Starting from the Receiver, the refrigerant in the form of liquid at high pressure is admitted to the Evaporator through a throttle valve known as the regulator or expansion valve. This regulator maintains the necessary differences of pressure corresponding to the required difference of temperature between the condenser and evaporator sides of the circuit. On passing through the regulator the fall in pressure results in evolution of vapour, the latent heat necessary to produce this being obtained from part of the liquid, which thereby becomes cooled to the temperature corresponding to the reduced pressure. The refrigerant entering the evaporator is therefore in the form of cold liquid containing a certain proportion of vapour. The liquid takes up its latent heat from the surroundings of the evaporator and leaves the evaporator in vapour form. The vapour coming out of the evaporator is sucked by the compressor and during compression the necessary increase in pressure is effected and the temperature of the vapour is also raised to a level sufficient to enable it to give up its heat to the cooling medium of the condenser. The hot compressed vapour passes on to the condenser where it gives up its superheat then its latent heat leaving the condenser as liquid and entering the receiver and the cycle is repeated indefinitely.

Now the various refrigeration machineries used in Fish Processing Technology are described below:-

REFRIGERATED SEA WATER PLANT:-

It is a well-known fact that fish can be stored for a couple of days without spoilage by chilling with ice immediately after catch. The same result can be achieved if the fish can be stored in Refrigerated sea water maintained at 0 to -1 °C with added advantage that the fish can be cooled much more rapidly and efficiently compared to ice storage.

In developed countries, the use of R.S.W. Storage has been widely used on board fishing vessel. In India none of the indigenous trawlers have started using R.S.W. except in some vessels on experimental basis. It is available in the imported Mexican type trawlers. CIFT has developed an R.S.W. Plant in the Laboratory and the arrangement is as shown in Figure 2.

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The storage tank and the chilling tank are made out of stainless steel and exterior body out of M.S. Sheet with 100 mm. thermocole insulation. Evaporation coil is made out of cupro-nickel tubing. The circulating pump has been used to circulate chilled sea water from the chilling tank to the storage tank and back. The condensing unit is using Freon -12 as refrigera

Installation of modified version of R.S.W. Plant on board fishing vessel of CIFT is in progress.

FREEZING MACHINERIES

There are four types of freezers used in fish freezing (a) Sharp freezer (b) Immersion freezer (c) Air blast freezer or Tunnel freezer and (d) contact plate freezer.

Sharp Freezer:-

In the sharp freezer, whole fish or packaged fish fillets to be frozen are placed on shelves comprised of refrigerated pipe coils. Eventhough the heat transfer between the refrigerant in the pipes and the fish at the point of contact is relatively high, the overall heat transfer rate is quite low because an extensive surface area of the product is not in contact with the pipes and is cooled largely by the natural circulation of the air within the freezer. So this type of freezer is not used now a days in modern plants.

IMMERSION FREEZER

Freezing by immersion of the fish in a cold liquid or by spraying is sometimes used because of its inherent simplicity and high output. In comparing with air liquids have much higher thermal capacities and thermal conductivity. Heat transfer can be rapid even with moderate circulation because there is good contact with the product. Immersion freezer will accommodate fish of various sizes and shapes but it will be more compact and consumes less power. In the direct method, the product is immersed or sprayed with a sodium chloride brine. In the indirect method, the product is contained in moulds which makes possible the use of other cooling media such as calcium chloride brine. Sodium chloride brine can be made upto any desired strength according to the desired freezing point of the brine. A saturated solution which contain about 26% salt, freezes at -21 °C.

In practice therefore, the operating temperature cannot be lower than about -19°C. This is a serious limitation because the refrigerant temperature should be below -30°C and the storage temperature should be -23°C or lower in most applications.

AIR BLAST FREEZER OR TUNNEL FREEZER

In this type of freezer, air at temperature of -35°C to -40°C is forced around the products at speeds ranging from 5 to 7 m/s. These freezers are generally constructed in the form of rooms or tunnels. These freezers are used for freezing such fishery products such as shrimps, fish fillets, breaded precooked products packed in packages. The main disadvantages of air blast freezers are that freezing times tend to be longer and it occupies more space and require more power than other types mainly because of the relative poor heat transfer properties of air. In some cases where distortion of fish frozen in the plate freezer is considered to be a disadvantage, the air blast freezer may be preferred particularly for whole fish which are to be frozen singly and then sold in the frozen state.

PLATE FREEZER

Plate freezers are of two types viz. horizontal and vertical types. In the horizontal type which is quite common in India (Figure 3) freezing is accomplished by refrigerant flowing through connected passageways in the horizontal movable plates stacked in an insulated cabinet. The space between plates is adjustable, usually by means of a hydraulic or pneumative ram which moves the plates up and down with one fixed plate at the bottom. There are flexible connections in the piping to the plates. Loading, by inserting the produce to be frozen between the plates and unloading, are done with the plates set at the open position. Both top and bottom sides of the product can be brought into contact with the plates before freezing and some compression may be exerted in order to reduce the freezing time. The plate freezer is particularly suitable where the produce is to be frozen in trays or in packs of regular rectangular shape with thickness upto 60 mm. Among packaged fishery products, frozen in the plate freezer are fillets, shrimp, fish sticks and fish blocks.

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In many respects the vertical plate freezer is similar in operation to the horizontal plate freezer. Unlike the horizontal plate freezer, however, it was developed primarily for the freezing of whole fish at sea on distant water vessels in order to supply processing factories ashore

ULTRA-RAPID FREEZING

Proposals have been put forward for the freezing of fish by direct contact with liquified gases which evaporate at very low temperatures at atmospheric pressure. The most notable of these liquid gases are liquid Nitrogen and liquid carbondioxide. Liquid Nitrogen has been used in refrigerated transport and in freezing for individual quick frozen (IQF) shrimp in many of the developed countries. (Fig.4). In freezing the rate of evaporat of Nitrogen at -196°C will be not less than 1 Kg. per kg. of fish. In additio there may be the requirement for the cold store and other losses. The cost of liquid Nitrogen is high compared with the conventional methods of refrigeration at -40°C.

Another method of rapid freezing recently introduced in developed countries is by spraying instead of liquid Nitrogen, food quality grade liquid Freon and recovering its vapour and recompressing and recycling. The cost of this method also is very high and it has not found its place in India.

FLUIDISED BED FREEZING

In this method the produce being frozen is fed on a conveyor and cool air at high velocity is passing through the produce in such a way that it is moving in a fluidised manner so that the freezing is considerably rapid (F.g5). This system also has not found its place in India owing to its sophistication.

FROZEN STORAGE

There are two types. The first is having cooling coils as long pipes fixed on ceiling and/or on the sides of walls with natural air circulation (Figure 6). The second type is with comparatively compact cooling coil with forced air circulation with blower. The two important requirements of a cold storage are that the temperature of the cold storage should be steady and should never rise above -23°C and the relative humidity in the

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cold storage should be as high as possible. The effect of temperature on the storage is very important as storage above -23°C even for a comparatively short period will result in rapid loss of quality. A high relative humidity in the cold storage will tend to reduce the evaporation of moisture from the product.

Jacketed store has been mentioned as an improvement in the cold storage practice. In a jacketed store (Fig.7) a sealed space is built all round on the cold side of the insulation. Cooling is provided in the jacket, so that the heat passing through the insulation will be taken up before it reaches the store proper, thereby the potential for dehydration and spoilage of the product is reduced. The cost of construction usually is higher than the cost for the conventional type of store, by perhaps 15% or so.

FREEZE DRYING

The principle of freeze-drying is illustrated in Fig.8. The material to be dried, whether it be solid or liquid, must usually be frozen by conventional methods before it is placed in the dryer The thickness of the material must be very limited to complete the process within a reasonable time. During the drying period a vacuum usually about 1 mm of mercury is maintained in the apparatus and the ice crystals are sublimed. The temperature of the ice front is determined by the vacuum, the vapour resistance in the already dried layer and the heat supply. The heat is usually supplied to the surface of the goods by conduction or radiation from heating plates. The residual humidity must be brought down to 1 to 2% to obtain adequate keeping quality. The dried porous material is hygroscopic and very sensitive to oxidation. It is therefore necessary to break the vacuum with a dry, inert gas usually Nitrogen. The product must be packed in vapour and gas tight containers under nitrogen. Correct freeze drying gives products of very high quality and excellent keeping properties under ordinary temperature. The process thus combines ome of the advantages of freezing and drying.

The material is protected by the low temperature against the denaturation and shrinkage associated with ordinary high temperature drying, and rehydrates quickly and nearly completely when it is used. The main disadvantage is the cost of production, including the high quality packaging. Only costly products

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such as shrimp can be freeze-dried in commercial practice and even this has not become popular owing to its high production cost.

REFRIGERATED TRANSPORT

For transport of frozen fish over longer distances and times, mechanical refrigeration systems are used. These systems are normally a mechanical refrigeration unit driven by an internal combustion engine, the cold air being force circulated around or through the cargo.

DRY ICE COOLING

In developed countries dry ice systems have been used both for long distance and local distribution vehicles. The system (Fig.9) has low initial investment as the basic equipment, apart from the insulated vehicle body, is very simple,merely a bunker for dry ice with a thermostaticaly controlled air circulating fan.

Normally the consumption of dry ice is very high thus resulting in high operating costs. Further more the CO2 rich atmosphere within the vehicle can be dangerous and ventilation will be necessary before the unloading operations.

CRYOGENIC SYSTEMS

Cryogenic liquid cooling systems have been used in developed countries, the most popular liquids being Nitrogen (-196°C) and CO2 (-78°C). The maincomponents are (figure 10) an insulated container for storing the liquified gas, a thermostat-operated valve and system of spray nozzles. The thermostat ensures that the air temperature is brought down to a proper level immediately after a door opening and this is achieved by the high expansion rate of these gases. One of the weaknesses of these systems is that they must be switched off when the doors are opened in order to prevent harm by suffocation freezing or toxicity.

The cost of these liquids are high hence these systems have not become popular in Indian conditions.

REFRIGERANTS USED

The most common refrigerants used are Ammonia (NH_3) and Freon -12 (CCl_2F_2). Freon -22 ($CHClF_2$) also is being used in some cases.

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BY PRODUCTS FROM FISH AND FISH WASTE

by

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Proper utilization of fish should to take into consideration the exploitation of all probable by-products derived from the inedible portions that constitute a substantial quantity of the fish carcass and also the bonny and tiny fishes which do not otherwise go as table fish. The traditional major fishery byproducts are fish meal, liver oil, body oil, fish maws and fins. Other important byproducts include liquid fish glue, gelatin and isinglass, pearl essence, fish skin leather, "fish albumin", peptones and amino acids, pet feed, fertilizer, certain biochemical and pharamaceutical products and fish protein concentrate. Utilization of prawn waste (the head and body peeling of prawns) from processing plants by way of extracting the protein and concentrating to shrimp extract and converting the skeletal material into useful chitin and chitosan is a recent introduction in the field of fishery byproducts.

FISH MEAL

Fish meal is a highly concentrated nutritious feed supplement consisting of high quality protein, minerals, vitamins of B group and other vitamins and other unknown growth factors. It is produced by cooking, pressing drying and grinding the skeletal remains along with the adhering proteinaceous tissues of fish from filleting or canning operations or by processing whole miscellaneous fish mainly caught along with prawns, which include jew fish, sole, silver bellies, ribbon fish and the like.

Traditional fish meal production in India was from the sun dried fish collected from various drying centres all along the coast and the product was chiefly used as manure. Better quality fish meal has been a prominent item of export from the very beginning of this industry. The importance of improving the quality for better use was felt and the Ministry of Food and Agriculture has, as early as in 1959, laid specifications regarding the quality of fish meal. Later the Indian Standards Institution has brought out the Indian Standards Specifications (IS:4307-1967 for fish meal as livestock feed for facilitating proper quality control.

Manufacturing process.

Fish can be reduced to fish meal by two general processes: (1) dry-rendering (2) wet rendering.

Dry-rendering

The dry-rendering or dry-reduction process is suitable only for lean or non oily fish such as silver bellies, jew fish, scianids, ribbon fish, sole, anchoviella, carcasses of shark etc., fish offal and filletting waste. In this process if the quantity of fish processed is very small, it is dried to a moisture content of 10% and pulverised. If the quantity to be handled is sufficiently large a steam jacketed cooker-dryer equipped with power driven stirring device is used. Sometimes, if the size of fish is comparatively large a coarse grinding is also done before being fed into the cooker-drier. The cooker drier may be operated at atmospheric pressure or under partial vacuum.

Being a batch operation the process will have only limited capacity and labour costs will be high. However, the water soluble materials are retained in the meal. It has the additional advantage for changing the operating conditions like cooking time and temperature depending on the raw material handled.

Rotary drum drier

For small fishing villages where large quantities of fish are not available rotary drum drier designed and developed at CIFT will be of much advantage. The drier used is a cylindrical rotating drum made of mild steel provided with baffles along the length in the inner surface. It is heated by steam in the jacket, temperature being controlled by regulating the supply of steam. An exhaust fan at the opening of the centre of the axial end of the drier draws out the water vapour from the drier, atmospheric air being sucked in through the holes provided at the other axial end of the drum. The process of cooking and drying is thus carried out simultaneously.

Dehydro-Mat drier

Renneburg's Dehydro-Mat Drier is designed on the principle of drying heat sensitive materials rapidly at high temperature for a short time without any damage to the product. The drier and the drying operation is devided into three stages.

The material is introduced first to the hot zone through a narrow diameter throat, at the feed end and is rapidly carried by hot air (high temperature and high velocity) through the first compartment. Drying in this hot zone is rapid but the surface damage is minimised by the cooling effect of the large amount of water vapourised during operation.

As drying progresses removal of internal moisture becomes increasingly difficult because of case hardening, as it reduces the rate of evaporation. During this stage the material is passed through a larger diameter drying section where because of the expansion of hot air the velocity and temperature reduces and consequently prolongs the time required for the material to pass through.

The partially dried meal is passed through the largest diameter section by the flow of air and held for a longer period allowing slow moisture removal at lowest air temperature and velocity and hence with minimum damage to the product and finally the material is discharged through a cyclone separator.

Wet-rendering

Wet rendering or wet reduction process is normally applied to fatty fish or offal where simultaneous production of fish meal and fish body oil are envisaged. The process consists of grinding, cooking to soften the flesh and bones and to release the oil, pressing to expel the liquor and oil, fluffing the press cake, drying, grinding and packing the meal, centrifuging the press liquor to remove suspended particles and to separate oil and concentrating the stick water. The process requires elaborate equipment and is normally a continuous one and therefore adaptable to the reduction of large quantities of fish.

In a continuous wet reduction process the coarsely ground or fresh raw fish or offal is passed through a stationery horizontal cylindrical cooker by means of a screw conveyor at a predetermined rate. Steam is admitted into the cooker through a series of jets. While the cooked mass is pushed forward by the conveyor the expressed liquid is allowed to drain through a screen on the bottom half of the cylinder. The cooked mass is passed through a continuous screw press. The press cake is fluffed and dried to a moisture content of about 8%. The suspended fish meal present in the press liquor is separated by centrifugal sedimentation and the oil by centrifugation or other conventional methods.

Composition

The composition of fishmeal differs considerably due to the variations in the processing conditions and raw materials used. The range of proximate analysis generally obtained is as follows:

Protein	50-70%
Fat	5-10%
Ash	12-33%
Moisture	6-10%

Fish meal is rich in all the essential amino acids, B. group vitamins and minerals particularly phosphorous and calcium. Because of this valuable composition fish meal finds place as important feed supplement to poultry and cattle.

Present status

During recent years organised fish meal industry has shown signs of revival. In 1972 there were seven such plants in the country with an installed capacity of 175 tonnes per day. About a dozen modern fish meal plants of the wet reductioh type are now in operation at various fishing centres.

Fish ensilage

Preservation of surplus fish and fish offal in liquid form for use as animal feed is an alternative for converting to fish meal. The process does not require heavy machinery and huge investment and therefore suitable for every fishing village.

Ensiling is achieved by treating the fish directly with mineral acid (sulphuric acid), organic acid (formic acid) or by producing lactic acid by fermentation to the required acidity for the preservation. In order to facilitate the production of lactic acid carbohydrate in the form of molasses is added to the fish or fish offal. The final pH will be around 4.5. In all the process the fish is partially digested and preserved by the acidity.

Liver oil

As early as the middle ages fish liver oils were used for the treatment of Vitamin A and D deficiency diseases. The therapeutic value of these oils was discovered in the 18th centuary and fish liver oil became a common medicinal product. Both vitamin A and D are found in certain fish liver oils. The most important fish liver oils are obtained from cod, haddock and shark. Halibut and tuna livers are also rich sources of vitamin A and D.

The weight of liver, fat content and presence of vitamins are dependent on species, age of fish, nutritional status and stage of spawning.

In Cod (*Gadus collarius*) coal fish (*Pollahius virens*), and haddock (*Melanogramnms aenglefinus*) the weight of liver normally amounts to 4 to 9% of the whole fish and livers contain about 45 to 67% oil. Species of shark such as dogfish (Squalus acanthias) Greenland shark (Somniosus microcephalus) and basking shark (Cetorhinus maximus) have large fat livers weighing 10-25% of the whole fish containing 60 to 75% oil. Halibut, tuna and whale have 1% liver having 4 to 25% oil with high vitamin A and D potency. Depending on the oil content and vitamin A potency fish livers are generally classified into 3 groups: (1) low oil content - high vitamin A potency (2) High oil content - low vitamin A potency and (3) high oil content - high vitamin A potency.

In India, a shark liver oil factory was in existance at Calicut in 1854 which had to be closed down due to competition of imported cod liver oil. The industry was revived in 1940 with the establishment of a shark liver oil extraction unit at Calicut by the Govt. of Madras.

Of the several species of shark available in our waters only certain species yield liver oil with high vitamin A content. The size of the fish ranges from 1 to 20 feet so also the liver, oil and vitamin contents. The potency of vitamin has been reported from 1000 to 353,000 international units per gramme and the oil content up to 80% of the weight of liver.

Production of oil

In order to obtain high quality light coloured oil with good flavour and odour, containing minimum free fatty acids, the fish is to be eviscerated and liver processed as quickely as possible. Special processing is required especially in low oil content - high vitamin A potency livers where the oil and vitamin A are held closely connected to the protenaceous liver tissue.

Processing of high oil - low vitamin a livers

In such livers the large volume of oil present act as a solvent for vitamin A thereby facilitating the extraction. The method of heating the fish livers with steam, either directly or indirectly was employed for extraction. The cooking results in the thermal rupture of the cells and releases the oil. If heated indirectly in steam jacketed kettles, it should be stirred mechanically to facilitate disintegration.

Low oil - high vitamin A livers

For such livers which contain only very low oil but high potency vitamin the direct or indirect steaming procedure will not release the oil with out degradation to vitamin A. In such cases the protein is digested and solubilized to release the enclosed oil and vitamin A or a solvent is used to extract the oil. The different methods of digestion employed are (1 alkali digestion (2) enzyme and alkali digestion (3) acid digestion.

Mild alkali digestion is the easiest and most general practice followed in many establishments. The process involves addition of 1-2% by weight sodium hydroxide or 2 to 5% sodium carbonate to the disintegrated livers and heating to 180-190°F with live steam while stirring. This results in the release of vitamin A and oil from the cell. The digested liquor is certrifuged while hot, to separate the oil.

Livers with very low oil content which do not yield their oil directly are minced and covered with any suitable oil and heated, with stirring, to extract the oil soluble vitamins and centrifuged. The process is repeated for further recovery of oil and vitamins.

Fish body oil

Fish body oil is extracted from whole fish or fish offal by wet reduction process, described under fish meal, particularly suitable for fatty fish such as herring, menhaden, pilchards, red fish, salmon cannery offal and oil sardine. The process is suitable for the recovery of oil from fishes that are low in oil content such as the trawler by catches when used for fish meal manufacture. The species that is used for extraction of oil should have high oil content, should be available in large quantities (at least during part of the season), the landings should be near the plant to become economical. Worlds established fish body oil industry are the Menhanden fishery of North America, Canadian herring, Mexican anchoveta and thread herring, Peruvian anchovy, North Atlantic herring, Japanese saury, squid, Pollock, Indian oil sardine, South African pilchard and anchovy.

Indian fish body oil Industry

The main source of fish body oil in our country is oil sardine. It was in the early 20's of this century that the sardine oil industry came into prominence in India. In 1922-23 a maximum production of about 12,500 tons of sardine oil has been recorded from 700 small extraction units. A survey of the oil industry reveals that the extraction is done on a cottage scale in some isolated places near the landing centres and is not well organised. The method of extraction followed is cooking the fish in iron vessels, most often without proper attention during the operation. Apart from sardine oil fish body oil is also obtained from the fish meal plants operating in the country.Production of fish oil has achieved considerable improvement both in quality and quantity in recent times due to the establishment of large organised modern fish meal plants.

Oil sardine is a fishery which has exhibited wide fluctuation showing a variation in contribution to the total fish landings from as low as 1% to as high as 32%. The fishing season commences with the premonsoon showers, the peack season being October to January. Seasonal variation is predominent along Karnataka and Kerala coast. The normal fishing area is in the coastal waters extending to 12-15 km from shore and at a depth upto 15m. During peak season the fish has an oil content up to 17%. By the wet rendering process the fish will yield, on an average, 12% oil having analytical characteristics similar to other fish oils such as British Columbia herring, Canadian pilchard. Fatty acid composition of the lipids of oil sardine has revealed that they contain high amount of poly-unsaturated fatty acids.

Industrial utilization

It has remained an age old practice of fishermen to use sardine oil for painting the bottom of their fishing crafts. A small portion of the better grade oil had been used for edible purpose. Other important applications of the low grade oil produced are in fat liquoring of leather, tempering of metals, batching of jute and in insecticidal soaps.

The high unsaturation, easy susceptibility to oxidation, flavour reversion and related changes create technological problems in its use in hydrogenated product, soap manufacture and domestic consumption. It has been reported that use of cold cleared sardine oil either as such or in admixture with ground nut oil can be successfully used as the medium in the canning of sardine. Hydrogenation done at atmospheric pressure is quite rapid and can bring down the I.V. to 100 when the typical rancid and fishy odour is removed and the oil is stabilised. Controlled dirdct interesterification of hydrogenated oil gives a butter like consistency. Refined sardine oil can be used in the manufacture of hard soap after hydrogenation at 100 p.s.i.g. and at 150 to 170°C using 20% Rufert nickel catalyst for 5 hours when the oil becomes hard pale white solid having I.V. 10. Neutral sardine oil can be split into fatty acids and by fractional distillation can be separated into three groups: (1) I.V.ranging from 65-82 (2) I.V.220 and (3) non distillable polymerised fatty acids and neutral oil. Fish oil fatty acids have found place in the manufacture of oil modified alkyd resins and paints and varnishes. Conversion of sardine oil into factice, as base for printing ink, as vehicle for surface coating, as an additive in lubricating oil etc. have been reported.

The demand of fish oil for use in food, pharmaceuticals, industrial products and intermediates in industrial chemicals and the technological progress being made in the field of production and utilization of the oil will broaden the market for fish oil.

Fish maws and fins

Fish air bladder also known as swim bladder, the compressible sac containing air, located in the abdominal cavity below the vertebral column, consists of several membraneous layers rich in collagen. In some fishes this air bladder is relatively large and redily detachable from the back bone and are therefore form good source for isinglass. The function of air bladder in fish is to regulate the specific gravity to enable it to maintain its position at any level in water.

Production

Air bladders of hake, sturgeon and carp are the main source of isinglass. In India it is obtained from eel, cat fish, carp and catla. The air bladder is seperated from the back bone during the dressing operation. They are then scraped and washed and temperorily preserved by salting. They are then split open, thoroughly washed and the black outer membrane is removed by scraping. They are then air dried and stored.

The dried bladders are softened by soaking in water for several hours, mechanically cut into small pieces and rolled or compressed between hollow iron rollers that are cooled by water and are provided with scraper for removing any adhering material. This process converts the isinglass into thin strips or sheets of 1/8 to 1/4 in. in thickness. They can again be pressed to very thin isinglass ribbons and are dried by suspending in warm rooms. Finally it can be rolled into coils. Isinglass is also produced in the form of leaf or book by suitable modification in the process.

Properties and uses

It swells in hot water, readily dissolves in most dilute acids or alkalis but insoluble in alcohol. It is used as a clarifying agent for beverages such as cider, wine, beer and vinegar, because of its fibrous structure which can enmesh the suspended impurities. It is also used as an adhesive base, in confectionery products, in India ink and as cement for glass, pottery and leather.

Shark fins

Apart from liver, fins, skin and teeth are also valuable products from shark fishery. Dried shark fin is an item of export from India mostly to Singapore, Hongkong and the United kingdom. Of the 37 species of sharks available in Indian waters, though fins from several species are exported, only a few fetch good prices, the maximum being fetched by "Ranja"(*Rhycobatus djiddeusis*). Other major varieties are Pison(Scoliodon walbheemi). "Khada" (*Carcharinus melanoptens*). Depending on the quality and quantity of rays present in the fins they are broadly classified into two varities, generally known as black and white. Dorsal, ventral/pectoral and caudal fins of both varieties are exported.

Processing

Fins are cut from sharks of about 125 cm. or more in length as soon as they are landed avoiding as much flesh as possible and are thoroughly washed in water after removing the adhering flesh. They are then dusted with salt in the ratio 1:10 (salt to fin), the cut portion being sprinkled liberally with salt. A little lime also is often sprinkled at the cut portion and are set aside for 24 hours. They are then dried after gently washing in clean water to remove solid salt and excess lime to a moisture content not more than 10%. The dry fins are graded according to the size and type of the fin.

The dried fins are further processed, for the "rays" they contain, into clusters or individual noodles. The process followed differs considerably from place to place. A typical process is described. The dry fins are soaked in 10% (v/v) acetic acid for 24 hours, taken out and the shagreen (calcareous material similar to scales in fish) is scrapped off. The adhering scrap residues are washed away with water and further soaked in the same acid till the muscle becomes soft. In the case of dry fins with 10-15% moisture the soaking is done for 4-5 days. Dried fins stored for longer periods may require longer soaking time or soaking in hot acetic acid for 1-2 hours. The skin and the softened muscle are scrapped off and the rays are separated from the flesh while washing with water. Alternately if the rays are to be extracted in clusters, as much flesh sufficient to hold the rays together at the base is retained. They are then washed free of acid and dried in sun or in an artificial air drier at 50-60°C to a moisture content of nearly 10%.

Though both white and black varieties of fins contain rays the yield from black variety is only about half that from white variety. Wide veration in yield exists in fins from different body parts. Yield of rays from dorsal and ventral fins is almost double that from dorsal fins.

Fins from black variety contain rays interspaced with cartilageous tissue which form the bulk and hence the low yield of rays whereas in the white variey the entire structure is constituted by rays. In candal fins, though massive in appearance, only the lowest portion contain rays. The projection to the upper or anterior corner contain only few small sized rays which neither have any good appearance nor lend themselves to smooth extraction.

Skin leather.

Skins of fishes especially of marine mammals like sharks, seals, porpoises, dolphins, salnion, skates and rays are generally converted to leather particularly suitable for manufacture of small novelties. Shark skin leather is a byproduct from shark fishery where shark liver is still used as a source for vitamin A.

The production process is essentially the same as that followed for making leather from animal hides as the principal constituent in fish skin is also being collaegen which forms leather with tanning agents.

The principal variation is that the scale or shagreen is removed from the fish skin while hair is removed from land animal skin. In the case of shark the shagreen is removed by chemical process and not by scraping which is a delicate operation. Vegetable tannages are generally used on shark and other fish skins.

Scale and shell

The lustrous effect of the irridescent material found on the epidermal layer and on the scales of most pelagic fishes is produced by the organic compound guanine, a constituent of cell nuclei. In its crystalline form guanine reflects and refracts light and acts a camoflague for fish. The guanine deposited on the fish scales are readily recoverable compared to that on the epidermis. The suspension of crystalline guanine in suitable solvent is called "pearl essence" and when deposited on hollow or solid beads they produce an opitical effect similar to genuine pearls. They are therefore useful in a variety of articles such as ash trays, fishing rods, book covers, finishes for textiles. The scales of carp, barracuda, bonito, shad, mullet, thread fin bream, jew fish are the main source for pearl essence.

Procedure

The scales are preserved by washing in 10-15% brine by gentle shaking. The brine is drained off and squeezed in muslin bags and stored at 32° F. At no time they are allowed to dry. Aqueous or non aqueous suspension of pearl essence are generally prepared. Aqueous suspensions are made by agitating the washed scales with water containing a little ammonia in an agitator resembling a domestic washing machine. It is then strained to remove the scales. The pearly substance present as the suspension in the liquor is purified by allowing to settle out in a cool place, decanting the supernatant liquid and repeated the process with fresh ammonical water, 0.3% salicylic acid is used as preservative.

Non aqueous suspensions are prepared by suspending in organic solvents or acids such as ethyl or amyl acetate, acetone, acetic anhydride, chloroform, carbon tetrachloride and acetic acid.

Shells of clams mussels and other byvalves are also commercially important by products from marine source. Clam shell is a major raw material for making lime. Mussel shells are used in many countries particularly in Australia and Far East for making buttons and similar items. In Japan it is being used for making spherical core matrices for the artificial cultivation of pearls.

Pharmaceuticals and additives

The importance of non fat components like Vitamin A, Vitamin D, cholesterol, lecithin, pigments of fish oils, glyceryl ethers and hydrocarbons, as pharamaceuticals and other additives are well known. Fish liver oil is an important source for natural vitamin A and D. New developments in this field are the reports that marine fungi make potent antibiotics, virus killing agents from ocean gastropods, anti cancer substances from other mollusca and potent antimicrobial agents from sea cucumbers. Certain steroids, pituitary hormones, insulin and enzymes can be extracted from the internal organs of certain fish and whales.

Insulin is one of such compounds of commercial importance. It can be extracted more easily from fish than from cattle. Fish insulin is more stable, not being subject to decomposition by protein splitting enzymes from pancreas. Insulin is a protein consisting of two polypeptide chains, one of 21 amino acids and the other of 30 amino acids joined by disulphide linkages between their cysteine components. It is present in substantial amounts in the islets or caps located on the gall-bladder of fishes like cod, halibut, pollack, tuna, bonito and whales. Such raw materials from the marine origin are being used in USSR and Japan for the manufacture of insulin.

Protamine, 5-iododeoxyuridine, desitin and cholesterol depressants are other items that are currently being manufactured from fish. Sea weeds is another commercially important raw material from marine source. The main constituent in sea weed is cellulose along with other polymer carbohydrate such as manitol, alginic acid etc. Agar agar is isolated and used as thickners for foods, pharamaceutical and microbiological laboratory work. Algin, agar and carrageerium are used as thickners, coagulants, flocculation agents and antibiotic carreers.

Corrals and sponges are also important items derived from the Ocean.

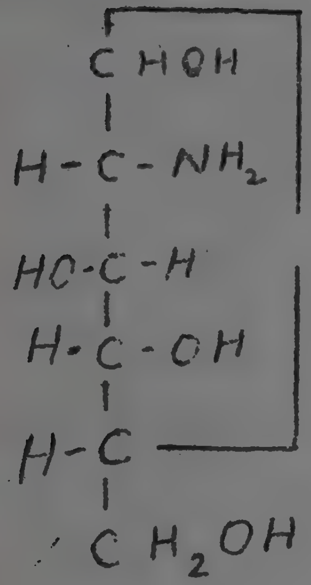
Prawns waste

The body peelings from crustacean processing plants in a major fishery waste where crustacea are abundant especially in the United States of America, India, Thailand Malaysia, Philippines, South Africa and Mexico. Shrimp and crabs and lobsters turn out very valuable, if properly processed; shell waste in sizeable quantities, the disposal of which now presents a serious problem. This waste contains a good percentage of protein and chitin other than minerals. The protein from this shell waste can be extracted along with the flavour bearing compounds and pigments and converted into shrimp extract having potential use as a natural flavouring material.

The chitinous skeleton from such waste and from other chitinous organisms like Antarctic krill, squilla caught along with prawns and the large quantities of fungi grown in fermentation systems producing organic acid especially citric acid constitute a potential source for industries based on chitin and its derivatives.

Chitosan, the deacetylated chitin is one of such compounds which has applications in many fields. It is a modified, natural carbohydrate polymer, 2-deoxy 2-aminoglucose. It is a cationic polyelectrolyte, insoluble in water, organic solvents, and alkaline solutions above pH 6.5 and is soluble in most organic acids (formic, acetic, tartaric and citric) and dilute mineral acids except sulphuric acid. It can form ionic bonds and films. Because of these properties chitosan finds application in many industries.

In India the quantity of such waste from prawn processing plants amounts to 50,000 tonnes annually. Squilla caught along with prawns throughout the west coast of India, being very difficult to separate the meat, is at present utilised only to a limited extend for making meal and the bulk of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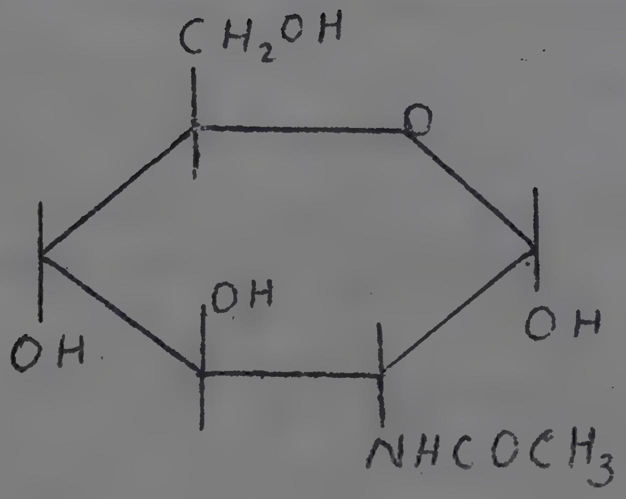
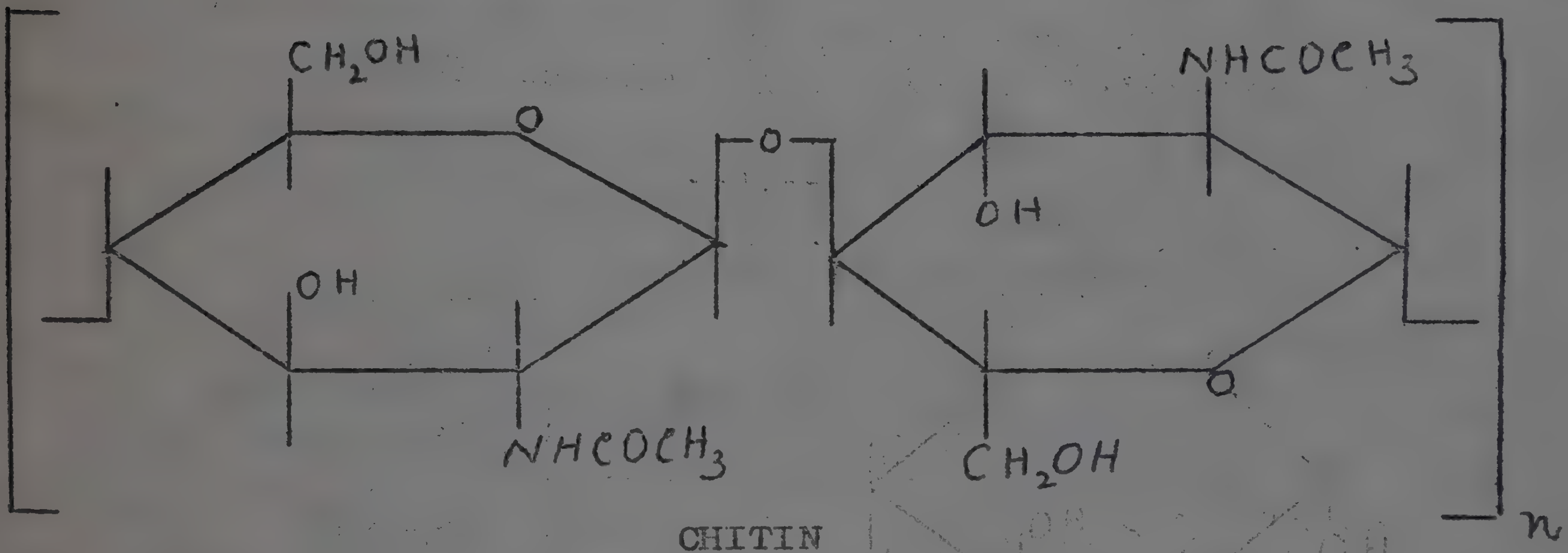
H-C-NH2
HO-C-H
H-C-OH
H-C
CH2OH

D-Glucosamine

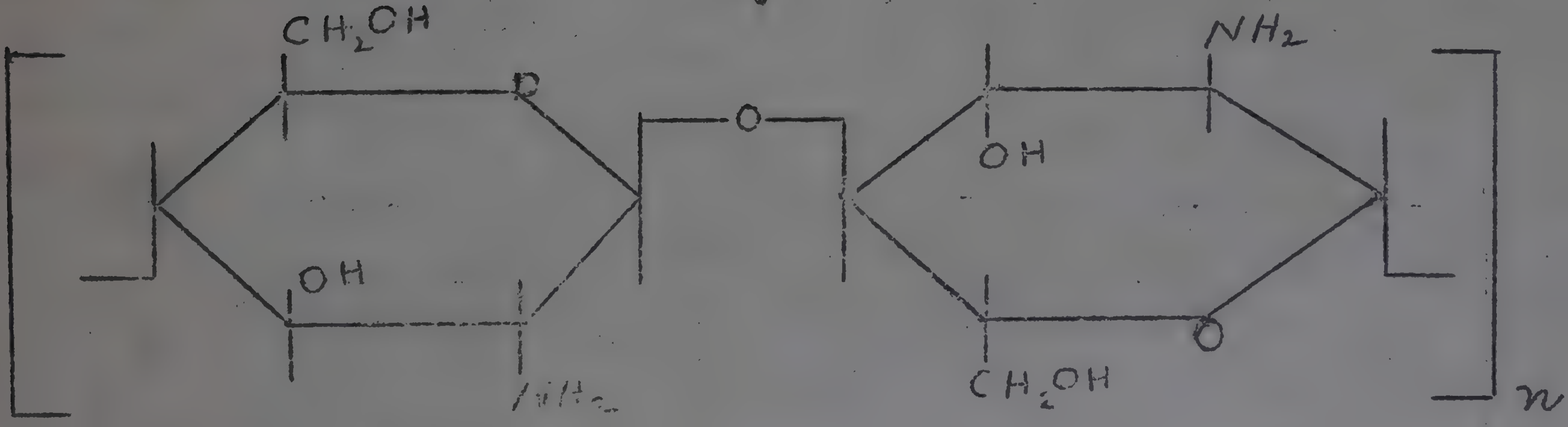

CH2OH
O
OH
OH
OH
NHCOCH3

N.acetyl glucosamine


CH2OH
O
OH
NHCOCH3
O
NHCOCH3
OH
O
CH2OH
n

CHITIN

Deacetylation


CH2OH
O
OH
NH2
O
NH2
OH
O
CH2OH
n

CHITOSAN

the catch is thrown back to the sea. The protein from squilla can also be extracted leaving the residual chitinous skeleton for industries based on chitin. Crab shell waste is yet another important waste of our marine catch. Similar to prawn waste the proteins from crab shell can be extracted for making crab concentrate and the remainder as raw material for chitin. Small non-penaeid prawns landed along the Maharashtra and Gujarat coasts, if processed for protein extract, will also form a good source of raw material for chitin.

Production

Chitin is isolated from the shell waste by separating the protein with dilute alkali and demineralising the skeletal portion with dilute acids. A final bleaching is done when ever necessary with dilute hypocholrite solution. The pure chitin thus obtained is deacetylated at about 100°C with highly concentrated caustic soda solution in water. The temperatufe and time of deacetylation will influence the quality of chitosan as drastic conditions will reduce the polymer length.

Applications

Though the properties of chitosan listed above can be made use of in many industries like, paper, food and drug, agriculture, pollution control, water treatment, textiles, paints, fibres, wrappings, thickness, coatings and film, it is not yet been commercially used till recently because of its scarce supply and the limited technical know how of the application by the industry. Waste water treatment, industrial flocculation and textile finishing are important fields of applications for chitosan.

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DIVERSIFIED FISH PRODUCTS

BY

K. Gopakumar
C.I.F.T., COCHIN -29

In India fishing industry is largely export oriented. Eighty percent of the country's exported commodities is comprised of prawns only. Prawns are caught by trawling operation. In these trawlers, apart from prawns, large quantities of miscellaneous fish are also landed during fishing. Their percentage may vary from 50 - 70% of the total catch while the shrimps accounts the remainder. However, when they are brought to the shore they fetch only a low market value. Since they form a cheap source of animal protein efforts are made to prepare diversified speciality products using them with a view to enhancing the commercial value of these by catch.

A variety of speciality products rich in amino acids, vitamins, minerals and other micronutrients can be prepared out of these fish. Some of the most common items are described in this article.

Fish Protein Concentrate (FPC)

Fish is a rich source of animal protein. However, vegetables and cereals supply worlds principal source of protein and calories. It is well known from the nutritionists' point of view that the vegetable proteins have to be supplemented by animal proteins since all of the essential aminoacids requirements are not met by them. Fish from time immemorial have occupied an important realm in man's food materials. But its preservation and storage have been a longstanding problem. Dry fish and fish meal are the two important ways of storage of excess fish the latter particularly on board the fishing crafts. A major requirement of any animal protein is its stability at room temperature so that it can be transported to distant places. Fish protein concentrate fully meets the above requirement. FPC is also fairly cheap besides being highly nutritive.

History of FPC

FPC was first prepared by the Romans. A vase unearthed in recent times from the ruins of Pompeii, Italy, describes a product prepared from fish which is akin to the present FPC. They described this as 'liquamen'.

In the last 25 years, largely due to the efforts of UNICEF, FAO and United Nations concerted efforts were made by several laboratories around the world to prepare a wholesome acceptable protein concentrate from fish. Several processes were subsequently perfected to prepare a colourless, odourless and tasteless protein concentrate from fish.

The first successful attempt to prepare a fish meal suitable for human consumption was made by G.M. Dreosti of South Africa in 1937.

Definition of FPC

The Protein Advisory group of the United Nations defined fish protein concentrate as follows

"Fish protein concentrate (FPC) is a stable product suitable for human consumption, prepared from whole fish or other aquatic animals or parts thereof. Protein concentration is increased by removal of water and in certain cases, of oil, bones and other materials. Traditionally dried or other traditionally preserved products do not fall within this definition."

Production Methods of FPC

1. Chemical

This process employs organic solvents to remove lipids and water from the raw or cooked fish meat. The finished product is a tasteless, colourless, odourless product.

2. Biological:

This uses fermentation techniques or enzymatic hydrolysis

3. Physical:

The method uses a high voltage current to separate components in the tissue of the fish.

Of the above three methods chemical methods are widely used in many parts of the world. The chemical methods necessitate the use of an organic solvent which should have the following properties.

1. It must be non-toxic to human being
2. Available in pure state
3. Easy and safe to handle

4. Low in price
5. Free from fire and explosion hazard
6. Efficient in removal of water and lipids as well as other odour bearing compounds without dissolving or reacting with proteinaceous components.
7. Low in B.P.
8. Suitable for solvent recovery and easy deodourisation.
9. Inert towards equipment construction materials.

Indeed no single solvent or group of solvents is known till today that can meet all of these major requirements.

Some of the important processes used for commercial production are given below:

The Viobin Process

This process was developed by Levin in 1964.

In this process raw fish is first mechanically ground into small particles. The pieces are suspended in ethylene dichloride and cooked to boiling by indirect steam. Ethylene dichloride (B.P.181 °C) forms an azeotropic solvent system with water (B.P.212 F) present in the fish meat. The azeotropic solvent system of ethylene dichloride and water has a low boiling point, 160°C, compared to the two solvents - water and ethylene dichloride. The azeotropic distillation removes water in vapour form and dissolves lipids simultaneously. The oil solvent solution, a miscella, is removed and the dehydrated, defatted fish meat is desolventised dried and powdered.

Canadian Process: (Due to Guttman and Vandenheuvel 1957)

It is a two stage process

Process A

Ground fish is suspended in water (pH 5.5) containing polyphosphoric acid and the whole mass is cooked for 30 minutes at a temperature of 167° to 172° F with constant stirring. It is filtered and the cakes are washed with hot water until filtrate is practically odourless.

Process B

The press cakes are suspended in isopropyl alcohol (double its volume) and refluxed for 15 minutes. The entire mass is filtered. The cakes

..4/-..

are pressed free of solvent and again washed with its double the volume of isopropyl alcohol. The fish cakes are pressed free of solvent, dried and powdered. The residual solvent is removed usually by vacuum drying.

British Process

In this process a completely tasteless, odourless fish powder is produced. Pulped fish is kneaded for 45 minutes with its own weight of acetone and solids are dried under vacuum. The dried fish pulp is kneaded and heated for another 45 minutes with its own weight of 90% (by weight) ethyl alcohol. The solvent alcohol is removed and residue dried under vacuum. The residue is again extracted with 90% alcohol (equal to half the original volume of fish). The solvent is removed and residue dried under vacuum and last traces of alcohol remaining in the solids are removed by sucking warm air through the mass. The dried fish meal is then pulverised, sieved and packed.

United Nations Processes:

Two processes were developed with the help of UNICEF.

1. Chilean Process:

FPC is prepared from hake. The process uses hexane followed by ethanol for extraction of carefully dehydrated raw material.

2. Moroccan FPC

FPC is prepared from a fatty fish, sardine. First fish meal is prepared by cooking and pressing. The pressed fish cakes are defatted by solvent mixture including hexane, ethyl acetate and isopropyl alcohol.

South African Process

It was developed at the Fishing Industry Research Institute, Cape Town, South Africa by G.M. Dreosti. The process employs ethyl alcohol for defatting the pressed fish cakes.

CFTRI Process

This process developed at Central Food Technological Research Institute, Mysore employs ethyl alcohol for defatting the cooked fish cakes.

..5/-..

CIFT Process

In this process comminuted fish meat was cooked with an equal quantity of water containing acetic acid (0.5 % by volume). It was left for an hour and the fish oil which separates on the top was skimmed off. The slurry was filtered through canvas bag and then pressed to remove water. The fat was extracted from pressed cakes,first with ethyl alcohol which also removes moisture from the cakes. It is them extracted with an azeotropic solvent mixture of hexane and alcohol (33.2 mole percentage of ethanol B.P.58.69°C). After the solvent extractions, the defatted mass was pressed in screw press and dried under vacuum. The dried FPC was steam stripped to remove the last traces of solvent, afterwards, it was again dried under vacuum and then powdered and packed.

Characteristics of FPC

Physical:

It is colourless, odourless, tasteless product, stable upto 2 - 3 years in room temperature with little changes in flavour.

Chemical composition of FPC prepared from Kilimin (Nemipterus japonicus) by CIFT Process

Moisture	- 8.1%
Protein (6.25 x N)	- 67.7%
Pepsin digestibility	98.0%
Available lysine(as % protein)	7.9 %
Total lipids	0.4%
Calcium	5.4%
Phosphorus	3.9%
Ash	24.1%

Food and Agricultural Organisation of United Nations proposed that FPC should be standardised into 3 classes A, B and C. Standards for Type A is given below:

Moisture (%)	10.0
Protein "	67.5
Pepsin digestibility "	92.0
Available lysine % of protein	6.5
Total lipids	0.75

...6/-..

Type B is fish meal which will have a fat content of 3% whereas type C is crude fish meat. It can have a fat content upto 10 percent.

Uses of FPC

FPC as such cannot be consumed. It can be incorporated as a protein supplement. Researches conducted at C.I.F.T. and elsewhere demonstrated that FPC could be safely incorporated in breads and biscuits upto 5 to 10 percent level.

It can be also incorporated in chappathis and other wheat preparations also.

Commercial Production of FPC

The most successful production of FPC and its marketing was recently achieved by Astra Nutrition A B of Sweden. This product has been used in large-scale trials in a number of countries. It is a type A FPC. Much of the production of Astra FPC was used by World Food Programme of United Nations to fortify wheat flour. Recently several FPC incorporated products like biscuits were developed by Astra. These products have been well accepted by a number of developing countries.

Future FPC

The use of FPC as a protein supplement will find its application in countries where there is a low protein intake. Since it is now well-known that most of the cereals contain fairly good amount of protein much of the protein malnutrition is actually due to low intake of those food itself. Hence, if these cereal based diets are consumed in sufficient quantities most of the protein deficiency symptoms can be overcome.

The cost of fish has recently increased at least by two fold. Recent development in transportation and preservation of fresh fish considerably enhanced the cost of fish. Hence, the cost of production of FPC has considerably increased in recent times. There is also restriction in use of FPC in many countries since solvent extraction is employed for defatting. Hence, FPC has not yet made a breakthrough in its use in many parts of the world.

FISH SOUP POWDER

Soup powder or soup tablets prepared from different food materials like protein hydrolysate, fat, meat, eggs and vegetables are in

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popular use in many parts of the world. These products are usually rich in protein, minerals, fat and vitamins. The fish soup powder prepared out of miscellaneous fish is also rich in protein and other nutritive factors. The method of preparation is given below.

1. Preparation of the material

Dress the fish free of head, viscera and scale. Cook the fish. Separate the meat out of the cooked fish. Gently press the fish meat in a cloth or canvas to remove excess water.

2. Incorporation of tother ingredients:

Fry the onions and corriander powder in the vegetable fat until the onions turn deep yellow to brown in colour. Add all other solid items starch, spices etc. and mix together. Cool to room temperature.

3. Grinding

First grind the cooked fish meat with equal quantity of water in wet soak food grinder mechanically for one hour. Add these the fried onions etc. to this mix and continue grinding for an additional half an hour to a very fine paste. CMC, abscorbic acid and MSG are added/and grinding continued for one or two minutes.

4. Drying:

Pour the paste into aluminium trays to about 1 to 2 cm. thickness and dry it under vacuum or under sun. Vacuum drying gives a white colour to the soup.

5. Powdering.

The dried soup cakes are pulverised in a blender to a very fine powder. Mix the milk powder at this stage with the soup powder. Pack the finished soup powder in airtight containers.

Recipe	Wt. in grams
Cooked fish meat	100
Salt	26.6
Fat (Dalda or Vanaspathy)	17.7
Onions (Sliced)	166.0

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Corriander powder	2.2
Starch (Tapioca)	44.2
Skim milk powder	17.7
Glucose	8.8
Pepper	2.2
Ascorbic acid	0.22
Sodium Carboxy methyl cellulose (CMC)	0.44
Monosodium glutamate (MSG)	1.32

Preparation of Soup

The soup can be prepared by boiling one part of the powder in 20 parts of water for five minutes.

Shelf life at room temperature One year

Fish Flakes (Wafers)

Composition of ingredients:-

Cooked fish meat (free of bones and skin)	2 Kg.
Corn flour	1 Kg
Tapioca starch	2 Kg
Sodium chloride	50 gm.
Water	3.5 litres

Picked fish meat is the most suitable one for this purpose

1. Homogenize the cooked fish meat with one litre of water for half an hour in mechanical grinder
2. Add starch, salt and the rest of the water and continue the grinding for another one hour or more until a very fine paste is obtained. Desired food colours can be added at the final stage of grinding to give suitable colours to fish flakes.
3. Spread the homogenised mass uniformaly in aluminium trays in thin layers of 1 - 3 mm thickness and cook under steam for 10 - 15 minutes.

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4. Cool to room temperature
5. Cut the cooked layer into desired shapes and dry under sun or in an electric dryer (maintained at about 45 - 50 °C)to a moisture level of 6 percent.
6. Pack the flakes in desired weights in polythene bags.

Storage life: About 2 years

Prawn flakes can be prepared if prawn meat is employed instead of cooked fish meat.

Kamaboko

It is a fish meat paste extensively popular in Japan. There are a variety of types of fish paste preparations popular in Japan known by the name Kamaboko. Fishes having a high percentage of myofibrillar proteins are selected for this purpose. The following species are suitable for the preparation of Kamaboko. Croaker, flat fish, sharks, cuttle fish, eel, flying fish. Kamaboko can be prepared from single species as well as from mixed varieties.

Method of preparation:

The fish are washed, scales head and viscera removed. After careful washing the fish are filleted. From the fillets bones are completely removed. Alternatively, the meat can be separated with the help of a mechanical meat picker.

The meat is then crushed with the help of a chopper roller or knives by hand. The crushed meat is then soaked in ice water for about 24 hours with occasional replacement of wash water with fresh water. Afterwards the meat is pressed in canvas bags to remove free water. The drained fish meat is ground in a wet food stone grinder for about half an hour. At this stage seasoning materials like sodium chloride, monosodium glutamate,sugar etc. are added along with starch and polyphosphate.(to give adhesion). The amount of starch required depends on the type of fish meat used. If the degree of adhesion of the meat is weak generally more starch has to be added. The grinding is again continued for some minutes. The fish paste is now ready for further processing.

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It is moulded into desired shapes upon thin wooden plates. This can be done either mechanically of manually. Wooden sheets made out of pine or cedar are usually employed for this. The fish paste spread on wooden plates is then cooked in flowing steam for about 80-90 minutes. The time of steaming depends upon the thickness of fish paste blocks varying from 20 (thin) to 80 (thick) minutes.

After steaming the fish meat paste (Kamaboko) is soaked in water for 10 minutes. This treatment imparts brilliant white colour to the product The blocks are now packed in polythene and sold. Its average shelf-life is about 2-3 days at room temperature.

Fish sausage

Fish sausage is perhaps the most important of the several specialit products available in the Japanese markets. Fish muscle having a low elasticity can be used for this purpose. Fish like tuna, marlin, salmon, white fish etc. can be conveniently used for the preparation of fish sausage. Tuna, having a good percentage of red meat can also be employed for this. However, fish like mackerel and sardine are not suitable for this preparation The colour of the meat has little importance since the end product is always coloured owing to the incorporation of synthetic colours in the mixing stage.

Method of preparation:

The fish is dressed by removal of head, tail, scales, visceral mass, bones etc. and skinned. The meat can also be conveniently prepared by a meat picking machine. The meat is suspended in fresh cold water to remove blood and other extraneous matters. The meat is then bleached. The bleached fish meat is drained mechanically using usually centrifugal separators. In certain cases when red meat is employed for the preparation of fish sausages it is usually dipped in a solution of sodium or potassium nitrite to increase the redness of the meat.

The bleached meat is ground in a grinder along with salt, vegetable oil, monosodium glutamate, sugar and preservatives to a fine paste. Spices, condiments and colouring mater are also added during the grinding. In order to increase the elasticity of the finished product (sausage), finely powdered starch is added towards the end of the grinding process. When grinding is stopped the white product is transferred to a mixer where it is well mixed with pork fat (7-10% by weight of ground fish meat).

The paste is then stuffed in synthetic or natural casings of size 5 cm width (half diameter) x 20 cm length. This size of packing will have net weight of about 131 g. The mouth of the casing is sealed with a sealing machine. The sealed fish sausage is heat processed at about 85 - 87°C for 60 minutes in a continuous cooker. Afterwards it is cooled in a continuous cooler (10°C) for 10 minutes. This cooling causes formation of wrinkles in the surface of fish sausage casings. These wrinkles are removed by soaking in boiling water for one minute. The fish sausage in the casings is again wrapped in cellophane paper and sold in markets.

The fish sausage is usually consumed along with the casings.

Types of synthetic casings used

1. Ryphan (Rubber hydrochloride : manufactured by Ryphan Industry Company, Tokyo)
2. Kurehalon (Vinylidene chloride manufactured by Kureha chemical Industry Company, Japan)

Both are tasteless and odourless.

Preservatives (used in Japan)

Sorbic acid and its sodium and potassium salts (2g/kg of sausage)

Furyl furamide (0.32 g / kg. fish sausage)

Typical Chemical Composition of fish sausage

Protein - 15%

Moisture - 68.6%

Sugar - 1.8%

Ash - 2.5%

Calories 141.5 per / 100 g of sausage meat.

Fish ham

Usually fish having red meat is selected for this. Tuna is an ideal choice for the preparation of fish ham. Small blocks of tuna red meat (1 to 2 cm^3) are dry salted with $NaCl$ 3 - 4 % by weight of the fish meat.

Usually sodium nitrite or potassium nitrite (0.1 g /kg of fish) is added along with salt. to impart more red colour to the meat. The reddened meat is then mixed with raw pork fat (20% by weight) and other condiments and ingredients(used for sausage) and ground to a fine paste. The paste is packed in suitable casings and processed as in case of fish sausage.

Fish Surimi

White muscle of the fish is used for the preparation of this product. Clean white meat is washed with ice cold water 5 or 6 time until it is free of the blood and other impurities. It is then pressed in hemp-sack o cloth bags to remove water.

To the pressed fish meat add 5 per cent (by weight) of sugar and 0.2% sodium polyphosphate. The whole mix is ground in a mincer or grinder for 15 minutes. The pasty mass is called surimi. It is then stiffed in small pans and frozen rapidly at -40°C until it is deep frozen, taken out from the pans, wrapped in polythene paper and stored at -20°C. The product has a shelf life upto 4 months under this conditions.

Fish Chowder:

Ingredients:

CookedFish meat	- 925 g
Cooked potatoes	- 925 g
Onions	- 25 g
Tomatoes	- 300 g
Salt	- 25 g
Pepper	- 7 g

The above ingredients are mixed together. It is then filled in cans. The cans are filled with a soup prepared out of prown meat and subsequently exhausted and seamed. They are then sterilized at 0.84 kg/cm^2 steam.

Fish Balls

They are usually prepared out of the white meat of lean fish. A common recipe is given below:

Cooked fish meat	- 500 g
Cooked potato slices	- 500 g

Refined hydrogenated fat	-	20 g
Sodium Chloride	-	15 g
Citric acid	-	1 g
Ascorbic acid	-	1 g
Pepper	-	To taste

The above ingredients are well ground in a medianical grinder for 15 minutes. The pasty mass is then shaped in the form of balls either by hand or mechanically which are then rotted over moist maida and then fried in any edible vegetable oil until brown in colour. The balls are then packed in cans. The cans are filled with a curry or soup and then exhausted, seamed and sterilized at 0.84 kg/cm^2 steam.

The composition of curry vary depending on the taste of consumers.

Recipe for a common curry:-

Fry 75 g onions in 10 g oil until brown in colour.

Prepare a broth consisting of 30 g minced prawn meat, 400 ml water and a paste of maida (10 g in 100 ml water). The fried onions are added to it. To 300 ml of this broth is added 100 g sliced tomatoes, 10 g salt and 4 g pepper. The curry is now ready for use.

Beche-de-mer

It is food product prepared from the body wall of the sea cucumbers. They are sausage shaped marine animals of the class Holothuroidea. The animals after washing to get free of slime and adhering dirt is processed to prepare Beche-de-mer. The viscera are removed. They are processed and sun dried or smoked. Beche-de-mer soup is a very much relished delicacy in China and throughout eastern Asia.

Fish Hydrolysates

Protein hydrolysate has become one of the major protein supplementary food items for children and convalescent persons. It is easily digestible, water soluble and rich in amino acids in their most assimilable form.

Preparation of fish protein hydrolysates

Fish hydrolysates can be prepared by a number of methods, most important ones being by hydrolysis by acids and enzymes.

Acid Hydrolysis:

Comminuted fish meat suspended in water can b hydrolysed by mineral acids (Acl and H SO4). Usually 2 - 6 N acids are used and hydrolysis continued for about 12-24 hours to get a completely water soluble product. The major disadvantage in acid hydrolysis is that it has to be conducted at a high temperature (80-100°C) and at the end of reaction the hydrolysate has to be neutralised to pH7 by alkalies. This introduces a large quantity of salts i the medium. Some of the acid labile amino acids are also lost during the hydrolysis causing loss in nutritive value.

Enzymatic hydrolysis:

This is the most convenient way of hydrolysis of proteins. The major advantage of enzymatic hydrolysis is that it is very fast and can be conducted at room temperature. There is practically little loss of amino acids. However, a suitable enzyme has to be selected for this purpose, the choice of which largely depending on factors like stability, cost etc.

If flavour of the end product is an important consideration, one has to select a more pure enzyme since the tendency to produce a bitter product decreases with increasing purity of enzyme. Some of the commercially available proteolytic enzymes are given below:

Pepsin, Ficin, Papuai, Trypsin, pancreatin, Rhozyme, HT proteolytic Prolase, Bromolein.

Ficic and papain produce a more bitter hydrolysate compared to bromolein. Bitterness is due to the production of polypeptides or peptides which are bitter in taste. Proper selection of enzyme and correct reaction time can give a hydrolysate which is practically odourless and slightly bitter.

Important factors in proteolysis

Structural changes of fish proteins take place during heating. The fish proteins during cooking become insoluble in the tissue fluid. If temperature is not properly controlled for proteolysis curdling and coagulation of minced meat take place rendering it impossible to hydrolyse. Introduction of lipids at the early stage facilitates hydrolysis since it helps the dispersion of the minced protein - water mixture taken for hydrolysis by formation of a stable lipid - protein complex. The presence of lipids prevents the agglomeration of protein particles. It also gives stability for the hydrolysate for easy decantation.

Extended enzymatic hydrolysis reduces the nutritive value of proteins by partial destruction of some essential amino acids. So the shorter the duration of the time of hydrolysis the better the end product, in terms of its nutritive value. The most commonly used enzymes for fish protein hydrolysis are bromolein and papain, the procedure are given below in detail:

Hydrolysis with Bromolein

Preparation of enzyme:

Commercial sample of bromelein is dissolved in 100 parts of citrate buffer, pH6 (citric acid & Sodium citrate, 0.1 M in water). Centrifuge and take the supernatant. This solution can be kept at 5°C for a week.

Preparation of water fat emulsion

10 parts of hydrogenated fish fat, antioxidant (BHA + BHT 0.01%) and 0.15 part sorbitan monostearate are mixed together and heated to 65 ° C for 15 minutes. Add water (containing 0.35 part sorbitan monotearate) by 90 parts to the mixture and homogenise in a blender and keep overnight. Next day the soluble oil - water emulsion is separated from excess fat and taken separately.

Take 100 parts minced fish meat, 20 parts water and 80 parts oil in water emulsion and homogenise in a blender for 5 minutes. To the resulting pasty mass add the prepared bromelein solution (6 parts by weight) and transfer the whole mass to a reaction vessel maintained at 57°C. The hydrolysis is continued for 15 minutes with continuous stirring. After the reaction is over the mixture is heated to 80°C for 12 minutes to deactivate the enzyme. The whole mass is again homogenised in a blender and then rapidly cooked to 5°C. The resulting fish hydrolysate is dried in a spray drier to get a fine powder.

Hydrolysis with papain

Comminuted fish meat is homogenised with water (1:1 wt./V) and the pasty mass is taken in a reaction vessel maintained at 50-55°C.

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Preparation of enzyme

About 25 g of the enzyme is taken in 100 ml distilled water and centrifuged. The clear filtrate is taken. Enzyme is added to meat mixture in the ratio of nitrogen contents (1:30).

Add the enzyme solution to the fish - water homogenate (maintained at 55°C ; pH 6.5) and continue the hydrolysis for 3 - 4 hours. After this th whole mixture is boiled to deactivate the enzyme. The mass is filtered thro filter paper to get the clear hydrolysate. It is concentrated under vacuum and then dried in conventional driers (vacuum drum drier or spray drier).

Use of fish hydrolysate

The hydrolysate can be incorporated in various food products to enhance the nutritive value of foods. It can also be mixed flavouring agents for the preparation of beverages, soups etc.

Bacteriological peptone:

It is a product prepared out of the fish meat. If hydrolysis is continued for about 8 - 10 hours using any of the enzymes mentioned above the end product will contain a large quantity of peptone, free amino acids and also some proteases. The resulting hydrolysate is called 'peptone' since peptones are the major ingredients in the hydrolysate. It finds extensive application in media preparations for the study of microorganisms.

Fish Stick

It was Rudy Wagner in 1949 who invented fish sticks. Fish sticks are produced from blocks of frozen fish by sawing. The size and shape varies from packers to packers. Usually they are uniformally shaped pieces of fish about 3 3/4 inch long. 7/8 in wide and ½ inch thick dipped in battr, breaded, usually fried and frozen in consumer size packages. Fish sticks are sold both in caked and uncooked form.

Preparation:

A good sized fish fillet block is usually taken for preparation of fish sticks. It is then deep frozen. The frozen fillets are automatically sawed into small blocks of size 3 3/4 inch long 7/8 inch wide and ½ inch thick

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The small fish sticks are then coated with a batter. The composition of a standard batter mix is given below:

	%
Wheat flour or corn flour	72.30
Salt	1.00
Baking powder	1.70
Dehydrated whole eggs	8.15
Nonfat milk powder	6.0
Melted hydrogenated vegetable shortening	9.0
Monosodium glutamate	1.85
	100.00

Preparation of batter

Mix all dry ingredients together in a blender. Add vegetable shortening after melting. After mixing cool in a freezer. It is then again powdered in a hammermil. Prepare batter by adding 1½ times its weight of water and mix thoroughly by stirring.

After coating with the batter the fish sticks are rolled over breading mix. The recipie of a suitable breading mix is given below.

	%
Wheat flower or corn flower	
Wheat flower or mixture of wheat and corn flowers	40.00
Dehydrated whole eggs	10.00
Non-fat milk powder	2.50
Salt	1.00
Fine cracker crumbs	45.85
Monosodium glutamate	0.65
	100.00

All the solids are mixed together to get a fine powder. This powder can be used for coating all types of fish sticks.

The breaded sticks are then fried in suitable vegetable oil immediately. The recommended temperature of the frying medium is usually about 190°C. About 2 minutes frying is only required to get a brilliant shade for the fish sticks. The finished product approximately will contain only 10% absorbed fat.

After frying the fish sticks are cooled to about 90°F before packing. This process is required since if they are packed warm moisture vapour will condense as frost within the package during freezing. The fish sticks are frozen in suitable packaging and sold in frozen condition.

Fish sticks are sold as an unfried product also.

Fish fingers

Fish fingers are prepared from fish meat. Fish meat is taken (either from single or mixed species) and it is freed from bones and skin. It is then mixed with sufficient cold water containing sodium polyphosphate (6g/1000 / g of fish meat) and the whole thing is mixed to a hard paste. Addition of phosphate gives a hard gel like structure to the mix. Usually sodium chlor is also mixed with phosphate solution.

The mixed hard pasty mass is transferred into trays of suitable size and then frozen at -40°C until it is deep frozen. The frozen blocks a taken out and cut into suitable shape (7 cm length x 2 cm width x 1 cm thic and dipped into batter, breaded, fried and frozen as in the case of fish sticks.

Fish fingers are sold in frozen conditions

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QUALITY CONTROL AND INSPECTION OF FISH & FISH PRODUCTS

By
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A. INTRODUCTION

The rapid expansion in fish harvesting, processing and marketing during the last fifteen years has been one of the hopeful signs in the growing crisis of food production. Fish production is expanding equally faster than any other food and contributes to about 10% of the worlds total animal protein food supply. At a time when resources are exploited to the practical limit, gains from the ocean will depend largely on better utilization of the harvest. Quality, Quality Control and Inspection are thus most important.

Quality does not always mean excellent. It varies with the consumer, the price he pays and the utility to which it is put. Quality is a degree of excellence. With regard to sea foods, quality is a cumulative effect of certain inherent factors like composition, nutritive value, size, species, sex, parasites and poisonous nature which are beyong the control of the Technologist as well as certain independent factors like the freshness, damage and deterioration during handling, processing and marketing on which adequate control can be exercised.

The object of Quality Control is to ensure that correct level of quality is achieved which satisfies the consumer for the money he pays. Quality Control consists of steps taken between harvesting and retail trade which protect the quality of the final product. In short Quality Control may be defined as the maintenance of quality at levels and tolerances acceptable to the buyer while minimising cost to the producer. Quality Control may be viewed from two angles 1) to prevent spoilage (2) to protect food from contamination which might render it unsafe or aesthetically objectionable. One of the greatest problems in fish handling in tropical countries is landing of fish free of spoilage. Even the most efficient and sophisticated processing techniques cannot undo deterioration which has already set in. Handling of fish between

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capture and delivery to the processor is the most crucial and it is probably during this phase that quality control efforts can be most rewarding.

Inspection is an official device to measure the effectiveness of a quality control programme and to protect the consumer and the trade. The enforcement of law and regulations does not by itself assure the development of a thriving industry. However regulations are necessary to protect the consumer by providing a uniform minimum standard of quality and to protect the industry from an unfavourable public image. A fish inspection programme can succeed only if it is developed as a cooperative effort with the government and the industry working in an atmosphere of mutual confidence and respect.

Quite contrary to the agricultural commodities, quality control of sea foods is quite unique. In the case of fruits and vegetables it is possible to select the right species, grow them to a desired level and harvest them at the appropriate time and place. Same is the case with animals and poultry. Whereas in the case of seafoods, the catch is from the sea from an unknown stock with regard to their age, size, sex and maturity. Hence the overall quality of the material varies in all possible combinations.

B. SET UP OF THE INDUSTRY

For technical reasons, the fish processing industry in this country is forced to carry out the entire operation in two different places under different managements. The preliminary processing is carried out in places what are commonly known as the primary process centres. Final processing like grading, freezing/canning, packing and storing are generally carried out in processing factories. In most cases the primary process centres are situated in villages whereas the processing factories are situated in urban areas. Fish processing units with an organised quality control set up are very few in this country. This is largely due to the small size of the units. In many cases the entire responsibility of purchase, production, quality control and marketing rests with one

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individual. This system has many disadvantages ad the time an individual can devote to different aspects is too short. All these will adversely affect the quality of the material. It is high time that the processors make a rethinking on the organisation of the whole set up and appoint separate staff for quality control work. Fish being one of the most perishable of all food materials thorough vigilance will be required from the time of catch till it is processed and packed. Staff responsible for quality control of processed product will formulate specifications for raw materials, inplant process, containers and finished product. Different sources of contamination will be located and remedial measures will be suggested. Development of sampling schedules, test procedures, recording and reporting of results and training of personnel also come under the responsibility of the quality control staff.

C. HYGIENE AND SANITATION IN SEA FOOD PROCESSING

1. Potable water:

All seafood processing establishments shall have arrangements for adequate supply of bacteriologically sound water. On an average 10-12 Kg. of water will be required for processing of 1 Kg. of fish. Survey conducted by the Institute reveal that only 50% of the processing factories have public water supply. Others have to depend upon alternate sources of water. When a factory depends upon non public water supplies, its quality and suitability to fish processing have to be analysed by a competent laboratory. Water used in the factory may have to be chlorinated to a residual level of 10 ppm and this water alone may be used in the different stages of processing and also for preparation of ice.

2. Ice:

Next important factor in the maintenance of bacterial quality of processed material is the use of sufficient quantity of bacteriologically sound ice. Apart from bringing down the temperature of fish thereby preventing bacterial growth, ice also helps in bringing down the surface bacterial load by washing out the surface slime by the melt water. But all the beneficial effects are lost if the ice used is bacteriologically

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defective. Ice may be prepared only from municipal water or water chlorinated to a level of 10 ppm.

3. Cleaning and disinfection

After finishing each day's work all the utensils used for processing may be hosed with water followed by scrubbing with a neutral detergent like teepol, spectrol or idet 5L. After washing off the detergent, the utensils may be disinfected by dipping in water chlorinated to a level of 100 ppm, giving a contact time of 15 minutes. The utensils may be given a rinse with potable water before processing starts. This cleaning schedule is effective in bringing down the bacterial load on their surfaces to permissible limits.

4. Handling of catch at sea

Fish has to be handled carefully right from the very beginning of catch as the quality of the landed material largely depends upon the care taken onboard trawlers. The boat deck, fish containers and other utensils on board vessels may contain millions of bacteria including faecal indicator and pathogenic organisms unless they are properly cleaned and disinfected. It is an important requirement that all the fish contact surfaces on board vessels may be adequately cleaned and disinfected after each day's work. Near shore waters shall not be used for cleaning as they are generally polluted. After each haul, the material may be graded, washed and iced as immediately as possible and under any circumstances not later than three hours after catch. Apart from spoilage it has been observed that delay in icing has a direct influence on the development of blackspots on shrimp. Icing should be done in alternate layers and in such a way that the fish does not come in direct contact with the sides of the fish hold or the containers. Not more than 3 feet depth of the material shall be stored in one container as otherwise the bottom layers are likely to be squeezed or bruised. Flake ice increases the cooling rate of fish because of more intimate contact between the ice and the fish. Ice left over after one fishing trip shall not be used for the succeeding fishing trip.

5. Transportation of the landed material

The landed material generally receives further mixing with ice before it is transported to the fresh fish market, the primary process centre or the processing plant as the case may be. The quality of the raw material reaching these destinations is once again likely to be affected by the condition of transportation, quality of ice used and the cleanliness of the containers used for transport.

6. Handling in processing units

a) All processing operations shall be done in premises especially meant for such purpose. In this context it should be noted that handling of the material in primary process centres designed and constructed with undue care on hygiene and sanitation will lead to contamination with extraneous materials and excessive numbers of bacteria including pathogens.

b) Plant premises shall be kept clean and waste shall be stored and disposed off in a systematic manner. There may also be provision for adequate drainage.

c) All processing halls may be fitted with doors and windows with flyproof nets and all possible measures may be taken to prevent the entry of rodents.

d) The floor, walls, ceilings, doors and windows shall be properly cleanable and washable. Floor may have sufficient slope to the drainage channels.

e) All processing operations shall be carried out on table tops. Surfaces with which the material comes in contact shall be made of non-corrodible, smooth non toxic and easily cleanable materials other than wood. Containers made of bamboo, wood etc. shall not be used.

f) Water of potable quality shall be available in plenty. Wherever public water supply is not available, the quality of the available water may be tested for possible presence of toxic substances, bacteria, hardness, alkalinity, free and saline ammonia, copper, iron, lead and arsenic and

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the water may be used only if it is certified to be satisfactory for fish processing. Chlorine at a residual level of 10 ppm may also be added to the water to guarantee good bacterial quality.

g) Ice shall only be manufactured from a certified water supply. Water for ice manufacture may be chlorinated to a level of 10 ppm. Ice shall be stored and handled in such a manner that bacterial contamination can be avoided. In storage rooms blocks of ice shall be kept only in raised platforms.

h) A system of cleaning schedule like the one mentioned above shall be adopted to all fish contact surfaces and floor. Cleaning and disinfection shall be carried out at the start, close of the day's work and at intervals.

i) Processing operation shall be orderly and fairly rapid.

j) Raw material shall be stored in suitable containers properly iced and they shall not be stored in such a way that the drained liquid from the top container falls on the contents in the bottom container.

k) Proper hand washing facilities shall be provided and workers handling the material shall be instructed to wash their hands from elbow down using soap followed by disinfection uring chlorine of 200 ppm strength.

l) Toilet facilities shall be of sanitary type and located sufficiently away from the processing hall. They shall be provided with hand washing facilities. A sign board indicating washing and disinfection of hands before leaving the toilet may also be displayed.

m) Chemicals like rodenticides, insecticides etc. shall be kept under lock and key.

n) Frozen storage rooms shall be provided with wooden scantling on the floor and the walls to facilitate circulation of cold air. Cartons shall be stacked in such a way that there is free flow of cold air among rows of cartons.

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o) Workers shall be provided with clean uniforms including foot-wear and head gear. Employees shall be medically examined before appointing them for fish handling and they shall be free from contageous disease and shall not be carriers of salmonella or other pathogens. They shall also be medically examined at trimonthly intervals and also on return after sickness. Longnails, nail polish, chewing, smoking, eating, drinking, gosspiing etc. are to be discouraged in the processing hall.

p) Any food additive or ingredient used shall be of approved quality.

D. INDIAN STANDARD SPECIFICATIONS FOR SEA FOODS

The Indian Standards Institution (ISI) is the national standards organisation in our country. The technical work relating to the formulation and revision of standards on sea foods are done by a Committee consisting of experts from manufacturing units, Scientific Organizations, purchase organizations and other concerned bodies. When a draft standard is formulated it is sent to experts in the line for comments. Based on the comments, the final standard will be formulated. So far there are 46 Indian Standards Specifications related to sea foods and sea food processing as shown in annexure-I. It is mostly based on these standards thatthe compulsory preshipment inspection is carried out. The main requirements for canned fish products and dried fish and shell fish are given in Annexures III and IV respectively. Annexure V gives the microbiological requirements for frozen and shell fish.

E. FISH INSPECTION

A number of fish items exported from this country are subjected to a system of compulsory preshipment inspection to guarantee that only good quality products leave this port. Every export consignment is to be accompanied by a certificate of export worthiness issued by a competent authority. Compulsory preshipment inspection of seafoods was started in India in 1965 by the Central Institute of Fisheries Technology. In early 1969, the responsibility was transferred to Export Inspection Agency. The year in which preshipment inspection for different seafood commodities was started is given in annexure II. No doubt the preshipment inspection system has considerably improved the quality of marine products processed and

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exported from this country

F. USUAL DEFECTS IN SEA FOODS

a) Poor quality raw material resulting from improper handling

b) Blackspots on prawn shell and meat resulting from delayed icing on board vessels and prolonged ice storage in primary process centres.

c) Weight loss on thawing due to separation of thaw drip.

d) Dehydration and freezer burn due to insufficient glazing, improper packaging and heavy fluctuations in frozen storage temperatures.

e) Blue/black discolouration in prawn and crab meat canned in brine due to presence of higher amounts of Copper and /or iron.

f) Under weight in canned prawns due to underblanching.

g) Bacteriological defect in canned products due to understerilization or post process contamination.

h) Excess percentage of water in fish packed in oil due to inadequate removal of mixture before filling with the oil.

i) Yellow discolouration in cuttle fish and squid due to delay in icing and removal of gut contents from the raw material.

j Poor quality packaging materials.

k) Presence of foreign materials like flies, hair, metal pieces, dried leaves, sand eledue to contamination during handling.

l) Excessive moisture, low salt, high admixture with sand pink and dun in cured/dried fish products.

m) Non conformity to size grades

n) Excessive numbers of inedible materials like shell pieces, vein, antinae etc. in certain products due to poor workmanship.

o) Poor bacterial quality due to inadequate hygiene and poor handling practices.

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p) Rancid odour and taste in oily fishes.

G. INPLANT INSPECTION

The system of inspection prevalent till recently in this country is end product inspection wherein only the end product is inspected and it is passed or rejected based on quality. The main disadvantage of this set up is that the material gets its green signal only at the end and in case of rejection at the end considerable amount of technology and money spent on the material will go as waste. In the new system contemplated namely, Inplant Inspection, the material will be checked for quality in different stages of processing by qualified and experienced Inspectors and only good quality material will be allowed to process further. It is understood that the processing units will also be graded as A, B, C etc. depending upon the facilities available in each units. It is hoped that such additional precautions will further improve the quality of marine products processed in this country.

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ANNEXURE - I

INDIAN STANDARDS ON FISH & FISHERY PRODUCTS

Sl. No.	Name of specifications	Specification No. and year of publication
(1)	(2)	(3)
	A. FRESH FISH	
1.	Fresh silver pomfret and brown pomfret	IS 4780 - 1968
2.	Fresh threadfin	IS 4781 - 1968
3.	Mackerel, fresh	IS 6032 - 1971
4.	Seer fish (Scomberomorus spp.) fresh	IS 6123 - 1971
	B. FROZEN FISH & SHELL FISH	
5.	Frozen prawns (shrimp) first revision	IS 2237 - 1971
6.	Frozen froglegs (first revision)	IS 2885 - 1975
7.	Frozen lobster tails (first revision)	IS 3892 - 1975
8.	Frozen threadfin	IS 4796 - 1968
9.	Frozen silver pomfrets and brown pomfrets	IS 4793 - 1968
10.	Mackerel, frozen	IS 6033 - 1971
11.	Seer fish (Scombermorus spp.) frozen	IS 6122 - 1971
12.	Frozen cuttlefish and squid	IS 8076 - 1976
	C. CANNED FISH & SHELL FISH	
13.	Pomfret canned in oil (first revision)	IS 2168 - 1971
14.	Prawns (shrimp) canned in brine (first revision)	IS 2236 - 1968
15.	Mackerel (Rastrelliger spp.) canned in oil (first revision)	IS 2420 - 1971
16.	Mackerel (Rastrelliger spp.) canned in brine (first revision)	IS 3849 - 1976
17.	Sardines (Sardinella spp.) canned in oil (first revision)	IS 2421 - 1971
18.	Sardines (Sardinella spp.) canned in brine and in their juice	IS 6677 - 1972
19.	Lactarius spp. canned in oil	IS 6121 - 1971
20.	Tuna canned in oil	IS 4304 - 1976
21.	Crab meat, canned in brine	IS 7143 - 1973
22.	Crab meat, solid packed	IS 7582 - 1975

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(1)	(2)	(3)
	D. DRIED FISH & SHELL FISH	
23.	Dried prawns (first revision)	IS 2345 - 1972
24.	Dried white baits (Anchoviella spp.)	IS 2883 - 1976
25.	Dried and laminated Bombay duck	IS 2884 - 1964
26.	Dry salted mackerel	IS 4302 - 1967
27.	Dry salted seer fish	IS 5198 - 1969
28.	Dry salted shark	IS 5199 - 1969
29.	Dry salted Surai (Tuna)	IS 5736 - 1970
30.	Dry salted thread fin (DARA) and dry salted jew fish (GHOL)	IS 3850 - 1973
31.	Dry salted cat fish	IS 3851 - 1966
32.	Dry salted leather jacket (chorinemus spp.)	IS 3852 - 1966
33.	Dry salted horse mackerel (Caranx spp.)	IS 3853 - 1966
34.	Dried shark fin	IS 5471 - 1969
35.	Fish maws	IS 5472 - 1969
	E. MISCELLANEOUS	
36.	Code of hygienic conditions for fish industry Part I pre-processing stage (first revision)	IS 4303 - 1975 (Part I)
37.	-do- Part II canning stage (first revision)	IS 4303 (part II) 1975
38.	Recommendations for maintenance of cleanliness in fish industry	IS 5735 - 1970
39.	Fish meal as livestock feed	IS 4307 - 1973
40.	Shark liver oil for veterinary use	IS 3336 - 1965
41.	Sardine oil	IS 5734 - 1970
42.	Glossary of important fish species of India	IS 7313 - 1974
43.	Basic requirements for fresh fish stalls	IS 7581 - 1975
44.	Basic requirements for a fish market	IS 8082 - 1976.
45.	Procedure for checking temperature of quick frozen foods	IS 8077 - 1976.
46.	Master cartons for Export of frozen seafoods and froglegs	IS 6715 - 1972

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ANNEXURE - II

DATES OF INTRODUCTION OF COMPULSORY PRE-SHIPMENT INSPECTION OF SEAFOODS

Type of product	Introduction date
1. Frozen shrimp	15th March, 1965
2. Canned shrimp	15th March, 1965
3. Frozen froglegs	1st March, 1966
4. Sharkfins & fishmaws	12th January, 1971
5. Dried fish & dried prawns	22nd June, 1971
6. Frozen lobster tails	28th December, 1971
7. Bacterial quality of cooked and frozen prawns	1968
8. Commercial sterility in canned products	1968
9. Bacterial quality of raw frozen shrimp (except total plate count)	August, 1973
10. Total plate count for raw frozen prawns	January, 1974
11. Canned crab meat	February, 1977

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ANNEXURE III

QUALITY REQUIREMENTS OF CANNED PRODUCTS

Sl.No.	Characteristics	Requirements for								
		Tuna O	Prawn B	Pomfrets O	Mackerel B	Mackerel O	Sardine B	Sardine O	Lactarius spp. O	Crab B
1.	Can exterior	Shall not be rusted, dented or bulged								
2.	Vacuum in mm(min) for round cans:	100 inall cases or negative pressure in flat cans								
3.	Head space mm	5 - 10 in all								150
4.	Drained weight of the contents of the can as % of water capacity	70	64	66	65	65	70	70	65	65
5.	Proportion of water in drained liquid(max)	5	--	10	--	10	--	10	10	--
6.	Disintegrated portion as % of drained weight (max)	5	5	5	5	5	5	5	5	--
7.	Trace elements ppm(max)	Cu 12	As 1	Pb 5	Zn50	Sn250				
8.	Can interior	Normal i.e. free from discolouration etc.								
9.	Microbiological activity	Absent in all cases								

O = Oil pack
B = Brine pack

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ANNEXURE IV

REQUIREMENTS FOR DRIED FISH AND SHELL FISH

Sl. No.	Characteristics	White Baits	Tune(surai)	Prawn pulp	Dried Bombay duck	Laminated Bonbay duck	Mackerel (dry salted)	Catfish (dry salted)	Dara (dry salted)	Ghol (dry salted)	Leather Jacket	Horse mackerel	Shark	Seer	Shark fin
1.	Moisture % (max)	20	35	20	15	15	35	35	45	40	40	40	40	45	10
2.	Sodium chloride % (max)	2.5	25	5	7.5	6	25	25	25	20	25	251	30	30	-
3.	Acid Insoluble ash % (max)	7.0	1.5	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

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ANNEXURE V

MICROBIOLOGICAL REQUIREMENTS FOR FRESH AND FROZEN FISH AND SHELLFISH

(Bacterial count maximum /g)

Sl. No.	Name of fish/shell fish	Fresh/Frozen	SPC	E.Coli	Coagulase positive staphylococci	Faecel streptococci	Salmonella
1.	Mackerel	Fresh	1,00,000	20	--	--	Nil
2.	Threadfin	Fresh	1,00,000	20	--	--	"
3.	Pomfrets	Fresh	1,00,000	20	--	--	"
4.	Mackerel	Frozen	1,00,000	10	--	--	"
5.	Threadfin	Frozen	1,00,000	10	--	--	"
6.	Pomfrets	Frozen	1,00,000	10	--	--	"
7.	Seer fish	Frozen	1,00,000	10	--	--	"
8.	Froglegs	Frozen	5,00,000	10	--	--	"
9.	Lobster tails	Frozen	5,00,000	20	100	--	"
10.	Prawns (whole & headless)	Frozen	5,00,000	20	100	100	"
11.	Prawns (peeled & deveined)	Frozen	10,00,000	20	100	100	"
12.	Prawns (cooked)	Frozen	2,00,000	Nil	100	100	"
13.	Cuttle fish	Frozen	1,00,000	10	100	--	"

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BACTERIA OF PUBLIC HEALTH SIGNIFICANCE IN FISH AND FISHERY PRODUCTS

B y
T.S. Gopalakrishna Iyer,
CIFT, Cochin-29

Raw whole fish taken from waters not polluted by sewage very rarely, if ever, contain pathogenic bacteria other than clostridium botulinum and Vibrio parahaemolyticus. But bacteria will be present in the gills, on the skin and in the intestines. So long as the fish is in the live condition these bacteria cannot do any harm to the fish muscle. When the fish is dead bacteria present both inside and outside will act upon the fish muscle converting the fish protein to many simpler products simultaneously producing several off smelling metabolites. Now the fish is considered spoiled and it is no more edible. Determination of total bacterial count therefore gives an idea about the extent to which spoilage has proceeded. But it should be remembered that even the freshest raw material handled and processed immediately after catch may turn dangerous to human health if handled under unhygienic conditions thereby allowing the entry of pathogens. These pathogens mostly mesophilic in nature get opportunity for rapid multiplication if kept inadequately iced. Some of the pathogens have the ability to produce toxins in the food material in which they grow. Ingestion of the toxin invariably leads to food poisoning. In certain cases no toxin is produced but the pathogen itself is capable of producing food poisoning. Hence adequate laboratory tests to detect, isolate and identify such pathogens are also carried out in the routine quality control procedures before the consignment is certified as fit for human consumption. Some of the organisms significant in fish from the public health point of view are discussed below.

Sanitary significance of faecal indicator organisms

At one time when the detection and enumeration of pathogenic organisms like Salmonella and Shigella was a difficult task, the use of the so called faecal indicator organisms like E. coli and faecal streptococci was the only possible method of assessing the sanitary conditions of processed foods. The underlying principle was that if the indicator organisms are absent, it is possible that the pathogenic

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types may also be absent. The indicator organisms originally suggested by Scardinger (1892) for this purpose was E.coli first isolated by Escherich (1887) from the intestinal content of human beings and later on supported by many workers by isolating the same organism from human and animal faeces in considerable proportions. Another organism which is also universally approved as an indicator organism is faecal streptococci which is also present in the stools of man and many warm blodded animals.

But now that there are many quick and reliable methods for the direct determination of these pathogenic organisms the question naturally arises whether these indicator organisms have any important role in modern hygiene. The answer must be in the affirmative for the following reasons.

1. First Salmonella as a rule is so heterogeneously distributed in foods and that a negative outcome of its detection has only limited significance.
2. Secondly apart from the classical pathogens of the genera Salmonella and Shigella other organisms may also be spread through foods and many of these especially the viruses and intestinal worms can be detected only with rather complicated methods beyond the scope of many food laboratories.
3. Thirdly the absence of enteric pathogens in a representative sample of food has significance only for the consignment under investigation. Repeated failure to isolate the organism is potentially valuable as foods prepared in the same way can ever be dangerously contaminated.
4. Finally, the detection of Salmonella in presence of an overwhelming majority of other bacteria present in the food is difficult.

5. These arguments clearly indicate that indicator organisms have still a place in protecting our food supply. But questions are often raised to distinguish faecal contamination from human faeces from those of animals, because these organisms are also present in the animal and bird excreta. But from the hygienic point of view all sorts of faecal contamination are equally dangerous whether originated from man or animals. Perhaps the estimated per capita output of these organisms/24 hr period is more from animal faeces than from human faeces. There are also authentic proof to the effect that pigs and birds are more frequent

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carriers of salmonella than is man. All these arguments focus to the point that all sorts of faecal indicator bacteria in food are equally objectionable irrespective of their source.

Factors judging the suitability of these indicator organisms in fish

E.coli: It is a gram negative rod shaped nonspore forming bacteria. Its presence in food is generally accepted as an indicator of faecal contamination in foods. The primary habitat of *E.coli* is the intestinal tract of many warm blooded animals. Natural water gets contaminated with *E. coli* either by direct contact or by mixing up with terrestrial sewage. When this water is used for fish processing, these organisms get entry to the product. Similar possibilities arise when the ice used for preservation or the utensils used for processing are contaminated with *E. coli*. Possibility of a direct contamination of food with faeces is rather remote and if at all happens it does not often exceed 25 mg of faecal mattor/10 kg of food which in turn give rise to 10 Enterobacteriaceae, 10 group D Streptococci and a few Clostridia/g of food.

But whatever may be the type of contamination, when once entered into a food product in considerable numbers it is very difficult to get rid of them completely. Even if the organisms are completely removed by some chemical treatment, the wholesomeness of the food cannot be guaranteed as many of the viruses and intestinal worms which are comparatively resistant to such treatments will be present in the product in viable forms. Hence it is better to process the material hygienically than to remove the contaminated bacteria in the final stage of processing.

Offshore water generally does not contain *E.coli* whereas incidence of this organism is usually noted in near shore waters. Fishing in these waters or washing boat deck and fish contaminers using near shore waters are proved to be primary sources for contamination with *E. coli*. Inadequately cleaned and disinfected boat deck and other containers used onboard trawlers also act as sources of contamination. It goes without saying that when the temperature is also favourable, the contaminated organisms multiply rapidly and further aggravate the situation. Eventhough *E.coli* is one of the most valuable indicator organisms it is very sensitive to processing conditions.

During icing of fish some amount of E.coli is leached out together with ice melt water. During washing with water chlorinated to a level of 10 ppm, more than 50% reduction in count takes place. About 95% reduction in E.coli count takes place during storage at -20°C and in a period of about 3 months complete destruction takes place.

Faecal streptococci

They are gram positive nonspore forming and nonmotile cocci which are found in human and animal faeces in large numbers and hence their presence in food has been well accepted as an indicator of faecal contamination. Just like E.coli, faecal streptococci are also absent in offshore waters. Unclean boat deck, utensils, water and ice are the major sources of Streptococci contamination to the product. Experiments have given clear indication that faecal Streptococci are comparatively resistant to many adverse conditions. About 30% reduction of faecal Streptococci takes place during freezing (-40°C) while during subsequent storage at -20°C not much of reduction takes place in count. Moreover faecal streptococci is also useful in determining the post process proliferation of faecal contamination in foods which cannot be detected by the use of much less resistant E.coli. These point to the superiority of faecal streptococci as an index of faecal contamination in foods.

Comparison of E.coli and faecal streptococci as indicators of food sanitary quality

Characteristic	E.coli	Faecal Streptococci
Morphology	Rods	Cocci
Gram reaction	Negative	Positive
Incidence of intestinal tract	10^7-10^9/g of faeces	10^5-10^8/g of faeces
Incidence in faecal matter of various animal species	Absent from some	Present in most
Specificity to intestinal tract	Generally specific	Generally less specific

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Occurrence outside intestinal tract	Common in low number	Common in higher number
Ease of isolation and identification	Relatively easy	More difficult
Response to adverse environmental conditions	Less resistant	More resistant
Relative survival in frozen foods	Generally Low	High
Relative survival in dried foods	low	high
Relationship to food borne intestinal pathogens	High	low

FOOD POISONING ORGANISMS ISOLATED FROM FISH AND FISHERY PRODUCTS:

1. *Staphylococcus aureus* (x)
2. Salmonella (x)
3. *Vibrio parahaemolyticus* (x)
4. *Clostridium perfringens* (x)
5. Enterococci (x)
6. Shigella

7. *Bacillus cereus*
8. Haemolytic streptococci
9. Virus of infectious hapatitis

(x) Important

1. *Staphylococcus aureus*:

Food poisoning caused by *Staphylococcus aureus* is very common. Only very few people escape this in their lifetime. Almost all foods especially the cooked foods are incriminated. The casuative organism is present on human skin, in boils, carbuncles, ulcers, sweat, eargum, throat and to a great extent in the post nasal drips of human beings recovering from cold. It has been estimated that about 30% of human beings are carriers of *Staphylococcus aureus*. Hence human element is an important factor in fish plant sanitation where human handling is unavoidable in some stage or other. Palms of the workers having some wounds or cuts in unprotected condition may harbour many thousands of *Staph. aureus* which will contaminate the material during handling of the material. Unnecessary talk during processing may result in the expellation of saliva containing *Staphylococcus aureus*. This may fall on the food material resulting in contamination.

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So improvement of worker's health, hygiene and general house-keeping are important factors to be given priority so as to avoid contamination with Staph aureus. A few Staphylococci/g of material may be harmless but food poisoning outbreaks may happen if the product is handled carelessly during later processing so as to allow multiplication of the organism in dangerous proportions. The organism can multiply vigorously and produce a toxin at temperatures near and above room temperature. Hence adequate refrigeration of the material during handling and processing is highly valuable in preventing further multiplication and toxin production. Staphylococci can also grow best in foods in which the competing organisms are present in low numbers like cooked foods. Eventhough Staphylococcus aureus are destroyed in temperature usually applied in the kitchen, the toxin formed already can withstand 100°C for more than 3 hours and hence are present in the material and if this exceeds 4 microgram/gram of the product, food poisoning takes place. Vomiting, diarrhoea, general malaise prostration etc. are the general symptoms which start within 1-6 hrs. after consuming the infected food. Complete cure is possible within 48 hrs. During freezing (-40°C) 5-10% of the organisms are destroyed while during frozen storage it gradually disappears and in about 8 months it is completely destroyed.

The most obvious control of Staphylococcus aureus in foods is to raise the hygiene of the workers and to enforce adequate control over the holding conditions like time and temperature.

Salmonella:

Perhaps no field is more confused and complicated than that of Salmonella in food poisoning. "Salmonella" is the generic name applied to a group of bacteria which was formerly known as "paratyhoid bacteria" which was derived by D.E. Salmon in 1885. Salmonella group of bacteria is composed of many serotypes and many new ones are still been isolated.

They are gram negative rod shaped bacteria mostly motile with the exception of S. pullorum and S.gallinarum. They do not form spores. Three clinically distinguishable forms of Salmonella are available.

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1. Those producing enteric fevers

   a) Typhoid fever : *S.typhi*

   b) Para typhoid fever - *S. paratyphi* A B & C

2. Those producing septicemia - This usually happens when the organism gets into the blood eg. *S. Choleraesuis*

3. These producing gastro enteritis:- All species except *S. typhi* and *S. paratyphi* produce gastro enteritis. Usually this happens on ingestion of food contaminated with Salmonella.

Primary habitat of Salmonella is the gut of man and animals especially warm blooded animals, mammals, birds and also insects lizards and snakes. From gut it is exerted out through faeces and hence found in sewage. Some people will be carriers of Salmonella.

Beef, mutton, fish, vegetables, egg and dairy products are incriminated in Salmonella food poisoning. Among food poisoning types of Salmonella, S. typhimurium is the commonest. Other common species include *S. thompson*, *S. newport*, *S. panama*, *S. anatum*, *S. Saintpaul*, *S. enteritidis*, *S. seftenberg*, *S. dublin*, *S.derby* and *S. infants*.

Symptoms: Salmonella food poisoning is caused by ingestion of foods containing sufficient number of Salmonella organisms. The onset of symptoms is usually within 12-24 hrs after consuming the infected food. Usual symptoms are nausia, vomiting abdominal pain, headache, chills, diarrhoea and fever. Symptoms are usually accompanied by prostration, mascular weakness,fainting, restlessness and drowsiness which last for 2-3 days. Mortality rate is about 4%. For the species *Salmonella Cholerae-suis* the highest mortality rate (21%) is reported.

But in the case of enteric fever producing species of Salmonella (*S.typhi*) the symptoms and course of the disease are more severe. Infection is by ingestion of the organism. From the small intestine they pass to mensentericus and after a period of multiplication they invade the blood stream and then come back to the gut. Liver, gall bladder, spleen, kidneys and bones marrow are affected. Fever, diarrhoea, restlesness, weakness, abdominal pain, severe headache and chills are the usual symptoms. Complete recovery is possible only within 20 days.

Preventive measures:

As they are pathogens of intestinal origin, improvement of personnel health and hygiene followed by adoption of necessary hygienic precautions alone can offer a permanent remedy to the problem of Salmonella in fishery products. Trimonthly medical examination of personnel handling the material, chlorination of water supply and adequate cleaning and disinfection of utensils can help a lot in the process of irradication of Salmonella.

Clostridium botulinum:

Clostridium botulinum is a food poisoning organism which produces a very deadly exotoxin when grown in foods. One gram of *Clostridium botulinum* toxin is capable of killing 109 mice. The food poisoning is called botulisum. The first record of botulisum was in 1793 and the etiological agent was first isolated in 1895.

Clostridium botulinum is an anaerobic gram positive spore forming rod and the spores are highly heat resistant. *Clostridium botulinum* type E is present in sea muds and is mostly involved in botulinum food poisoning in seafoods. Food poisoning is due to ingestion of toxin and not the bacterium. Hence it is a must that the infected food material may have to be held in favourable condition for multiplication of the spores and formation of the toxin. Symptoms develop within 12-24 hrs. Nausea, vomiting, fatigue, headache, paralysis of the muscles, difficulty to talk, dryness of the skin, mouth and throat, double vision and sound in the year are the usual symptoms. Death is due to respiratory failure. Mortality rate is very high (31-65%).

Clostridium botulinum food poisoning is a problem mostly in home canned foods that are improperly handled and insufficiently heat processed. Proper processing under hygienic conditions and adequate retorting will solve the problem.

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Clostridium welchii

It is a gram positive anaerobic rod shaped spore forming bacilli producing food poisoning in many kinds of foods including fish and fishery products. Unlike in the case of botulinum food poisoning, in this case the actual organisms are the cause for the poisoning. Food poisoning strains of Clostridium welchii existin soil, water, dust, spices and intestinal tract of man and animals. Food products contaminated with Clostridium welchii from any of these sources multiply under favourable conditions and result in food poisoning. Upon ingestion of contaminated foods, symptoms appear between 8-22 hrs. Symptoms are characterised by acute abdominal pain diarrhea, nausea and fever. Vomiting rarely occurs. Except in elderly or debilitated persons, the illness is of short duration, one day or less. Mortality rate is quite low or nil and no immunity seems to occur.

Improvement of sanitary conditions of the processing establishments, chlorination of water supplies, disinfection of utensils and other food contact surfaces and thorough check on employee hygiene and health are suggested as preventive measures to avoid problems of Clostridium welchii in fish and fishery products.

Vibrio parahaemolyticus:

This was first isolated in Japan in early 1951. Problem of vibrioparahaemolyticus food poisoning is more in countries like Japan where there is a habit of eating raw fish. This is a gram negative, motile, non spore-forming Vibrio usually present in marine mud, plankton and sea water. It has an extremely rapid growth. Grows faster than any other organism for which growth rate has been determined. In many bacteria generation time is about 20 minutes. But in the case of Vibrio parahaemolyticus it is 7 minutes. Hence an initial contamination of fish with this Vibrio followed by improper icing will result in the multiplication of the organism and production of food poisoning on consumption of the fish. Food poisoning in the case of Vibrio parahaemolyticus is due to ingestion of the organisms and not due to any toxin. Onset of symptom is within 12 hrs.

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after ingestion of food. Abdominal pain, vomiting, diarrhoea and fever are the usual symptoms. It may turn fatal if proper care is not taken in time. *Vibrio parahaemolyticus* cannot grow below 5.8°C. Maximum temperature for growth is 45°C. At 48°C 95% of the bacteria are inactivated. 99.9% of *Vibrio parahaemolyticus* are destroyed during freezing at -40°C and in storage at -20°C the rest also will be destroyed within 10 days. Improvement of hygienic conditions and chilling the material immediately after catch are suggested as preventive measures.

SHIGELLA

It is a gram negative non-motile rod shaped organism first isolated in 1898 by Kiyoshi Shiga in Japan. This organism is more resistant to external influences than other intestinal organisms. Thermal death point is 60°C. They can survive in infected water and soil for considerable period of time. These organisms gain entrance to the body by ingestion of infected food. The organism pass the acid barrier of the intestine and multiply in the gut and produce ulcertion of the large intestine followed by dysentery.

Bad hygienic conditions help in the spread of infection. Man is the source of infection. Food materials are contaminated by flies and man.

Preventive measures include improvement of general sanitation, protection of food from flies and control of carriers.

Bacillus Cereus:

Bacillus cereus is an aerobic spore forming rod shaped bacteria normally present in soil, dust and water. This is a food poisoning organisms usually creating problem in cereal dishes, mashed potato, cornstarch and the like. Fish and fishery products are not usually incriminated. Symptoms consist of nausea, abdominal cramps and watery stools. Minimum number of organisms required to produce food poisoning is 10^7/g. Toxins are not demonstrated. The organisms cannot grow below 10°C. So proper icing can prevent multiplication of the organisms. Being a soil organism, handling of shrimp on floor of the processing hall may result in contamination with *B.cereus*.

In spite of the fact that it is possible to prevent outbreaks of food-borne disease, they are unfortunately not completely prevented. Safeguarding the supply of foods by a repressive system i.e. sampling followed by comparison of the bacteriological condition of the samples with standards for wholesomeness and rejection of lots yielding substandard samples is not a permanent solution to the problem. Protection of the consumer against food borne disease and maintenance of the reputation of the manufacturer must therefore be based on a preventive approach.

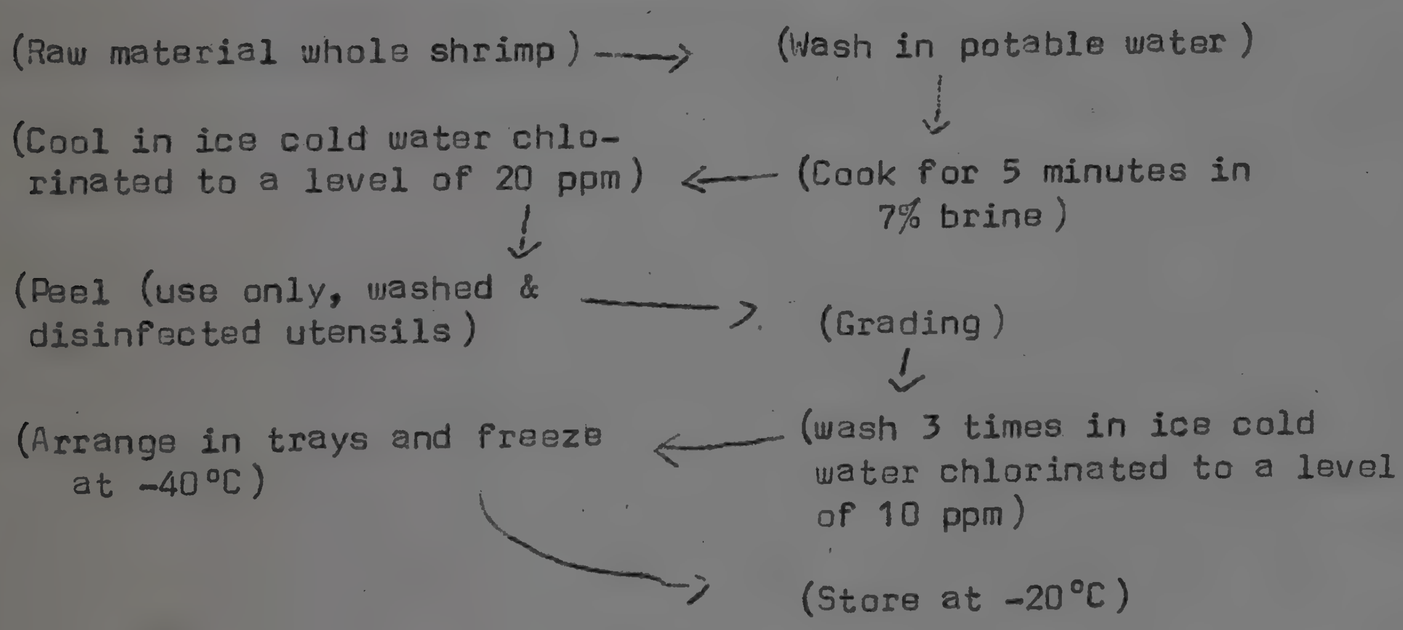
Based on the aforementioned facts, methods have been developed in CIFT for prevention of bacterial contamination in fish and fishery products, two of which are given below. Method developed for cleaning and disinfection of utensils is also discussed.

Cleaning Schedule

for utensils and equipments in fish processing factories

1. wash the utensils in running potable water
2. Clean with a neutral detergent to remove slime and dirt.
3. Dip in water chlorinated to a level of 100 ppm for 15 minutes.
4. Wash in potable water.

Preparation of bacteriologically sound cooked peeled frozen shrimp


(Raw material whole shrimp)
(Wash in potable water)
(Cook for 5 minutes in 7% brine)
(Cool in ice cold water chlorinated to a level of 20 ppm)
(Peel (use only, washed & disinfected utensils)
(Grading)
(wash 3 times in ice cold water chlorinated to a level of 10 ppm)
(Arrange in trays and freeze at -40°C)
(Store at -20°C)

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Preparation of frozen froglegs free of Salmonella

1. Wash the live frogs in potable water followed by washing with water chlorinated at a level of 200 ppm
2. Paralyse the frogs by dipping in 10% solution of common salt for 10 minutes
3. Cut off the pair of hind legs in such a way that the intestines are least disturbed.
4. Legs with the skin are dipped in 3% brine containing 200 ppm available chlorine.
5. Remove the loosely hanging intestinal portions and wash in potable water.
6. Dip the skin on legs in 5% brine containing 500 ppm available chlorine for 15 minutes.
7. Remove the skin and dress the meat.
8. Remove the cloacal portion and clean.
9. Wash three minutes in water chlorinated to a level of 200 ppm the last washing may serve as a dip for 10 minutes. It will be preferable to give a final washing with water chlorinated to a level of 10 ppm to remove any excessive smell of chlorine.
10. Wrap individually, freeze at -40°C and store at -20°C.

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STATISTICAL METHODS
IN FISH PROCESSING TECHNOLOGY

by

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Cochin

1. Introduction

Statistical techniques can be applied in industries for improvement of quality and reduction in wastage at different stages of production. In food industry also quite a good number of statistical techniques find applications and if used with discretion, can lead to better quality products at lower costs. While knowledge of mathematics is necessary for advanced methods, most of the day to day applications can be managed with less complicated techniques. In what follows we will consider some of the applications under different topics. Many more applications which can be used in food industry, can be found in the books recommended at the end of these notes.

2. Measures of Central Tendency and Dispersion

Very often collection of routine data is maintained at different stages of production in a factory. They may have to be summarized to make them comparable with previous or subsequent data. Daily production figures for instance, would be required to find lean and peak seasons. Hourly data on number of items turned out at any stage could be utilised to fix standards of performance. The summarization of such type of data is achieved by calculating two measures, known as measures of central tendency and dispersion. While different measures for these are available, the most frequently used are 'mean' as measure of centfal tendency and 'range' or 'standard deviation' as that of dispersion. The calculation of these can best be illustrated with some specimen data.

Consider the following ten numbers:

5,8,7,6,9,12,10m 6,9,8

Denoting by 'n' the number of numbers and X for the value of each number we have the following.

$n : 10$

Sum of X : $S(X) : 5 + 8 + \ldots\ldots + 9 + 8 = 80$

Sum of X^2: $S(X^2): 5^2 + 8^2 + \ldots\ldots + 9^2 + 8^2 = 680$

Mean (X): $\frac{\underline{S(X)}}{n} = \frac{80}{10} = \underline{8.0}$

Square of standard deviation (known as variance) :

$$s^2 : S(X^2) - (S(X))^2/n = \frac{680 - \frac{80^2}{10}}{10}$$

$$= \frac{680-640}{10} = \frac{40}{10} = \underline{\underline{400}}$$

Standard deviation (S) = $\sqrt{\text{variance}} = \sqrt{4.0} = 2.0$

Range (R): Maximum value - Minimum value = 12-5 = 7

Mean, standard deviation (or s.d) and range are commonly denoted by $\bar{X}$, S, and R respectively.

When we deal with bulk data, where the observations might be running to a larger figure, we tabulate the data as frequency distribution and carry out the calculations. (The data are tabulated as frequency in each class).Denoting the mid-point of each class by class value 'X' and the number of observations in each class as frequency 'f' let us consider the following data.

Table - 1

Class	Class value (X)	Frequency (f)
8 - 12	10	1
13 - 17	15	17
18 - 22	20	25
23 - 27	25	86
28 - 32	30	125
33 - 37	35	77
38 - 42	40,	55
43 - 47	45	9
48 - 52	50	4
53 - 57	55	1
Total		400

When we deal with grouped data as above, correction factor is necessary in the calculation of variance / S.d. ∠to be obtained as the square root of the corrected variance.

The necessary calculations are as follows:-

n : 400

$S(f\,X) : 1 \times 10 + 17 \times 15 + \ldots + 4 \times 50 + 1 \times 55 = 12,220$

$S(f\,X^2) : 1 \times 10^2 + 17 \times 15^2 + \ldots + 4 \times 50^2 + 1 \times 55^2 = 393,750$

$$\text{Mean} : \frac{S(f\,X)}{n} = \frac{12,220}{400} = \underline{30.55}$$

$$\text{Variance, uncorrected} : \frac{S(f\,X^2) - \frac{(S(f\,X))^2}{n}}{n}$$

$$= \frac{393,750 - \frac{12,220^2}{400}}{400} = \frac{393,750 - 373,321}{400}$$

$$= \frac{20,429}{400} = \underline{51.0725}$$

$$\text{Variance, corrected} : 51,0725 - \frac{5^2}{12} = 51.0725 - 2.0844 = \underline{48.9892}$$

$$\text{S:D, corrected} : \sqrt{48.9892} = \underline{7.00}$$

∠ A quantity equal to the class length (here 5) squared and divided by 12 has to be subtracted from the variance, and s.d.

The calculations on grouped data can be simplified by taking arbiratrary origin and coding the data in terms of class length. The values of mean and s.d will be same by this method of calculation also.

3. Control Charts

The produced items in any production process will not all be identical in every respect. Certain amount of variation in one or more of the quality characteristics is inevitable. This variation is considered to be arising due to two sets of causes, known as chance causes and assignable causes. The variation due to chance causes is uneconomical to trace and eliminate, and hence is taken as part of the normal process itself. On the other hand, the variation due to assignable causes when arising, should be quickly eliminated to maintain uniform quality of the product and to reduce wastage etc. These assignable causes may be operating at any stage of the production. Control chart is a technique which can be used to trace this variation. We illustrate the application of this technique with reference to data obtained on fill - weights of shrimp in a canning factory. In this application we maintain two parts of a chart known as $\bar{X}$ - R chart, for means and ranges respectively.

Data presented in Table 2 pertain to ten sets of 5 cans each, taken at intervals of 20 - 30 minutes, from the weighing line, between each set. The figures represent the excess of weight of shrimp, filled over the minimum instructed fill - weight, in grams.

From each set, mean and range are arrived at, making use of formulae explained earlier. The mean of/ means $(\bar{\bar{X}})$ and/ mean range $(\bar{R})$ are calculated. Next the preliminary control limits for means and ranges are to be calculated for which we require two values from standard tables available for this purpose. These values are denoted by A_2 for means, and D_3, D_4 for ranges and depend only on the number of units included in each set. For a set of 5 as was taken here, the values are A_2 : 0.577, D_3 : 0 and D_4 : 2.114. The preliminary control limits are to be calculated for $\bar{X}$ - chart (chart for means) and R - chart (chart for ranges) separately. The upper contfol limit (u.c.l.) and lower control limit (L.C.L.) for each chart are given as follows:

$\bar{X}$ Chart U C L : $\bar{\bar{X}} + A_2\bar{R}$

L C L : $\bar{\bar{X}} - A_2 \bar{R}$

R Chart U C L : $D_4 \bar{R}$

L C L : $D_3 \bar{R}$

TABLE 2 PRELIMINARY LIMITS FOR CONTROL CHARTS:OBSERVATION TO THE NEAREST GRAM OVER THE MINIMUM FILL WEIGHT

	I	II	III	IV	V	VI	VII	VIII	IX	X
	7	5	8	9	6	8	3	8	2	4
	9	8	5	6	11	5	7	4	6	3
	8	6	10	10	9	12	9	5	7	4
	6	6	9	10	5	7	5	3	5	5
	6	5	9	8	10	5	8	4	8	4
Sum	36	30	41	43	41	37	32	24	28	20
X	7.2	6.0	8.2	8.6	8.2	7.4	6.4	4.8	5.6	4.0
R	3	3	5	4	6	7	6	5	6	2

$\bar{\bar{X}}$: 7.2+ ..... +4.0/10 = 66.4/10 = 6.64 A2 : 0.577 D3 : 0
D4:2.114

$\bar{R}$: 3 + ... 6 + 2/10 = 47/10 = 4.7

$\bar{X}$ Chart : U C L : $\bar{\bar{X}} + A_2 \bar{R}$ = 6.64 + 2.71 = 9.35

L.C.L : $X - A_2 \bar{R}$ = 6.64 - 2.71 = 3.93

R Chart ; $UCL : D_4 \; \overline{R} = 9.94$

$LCL : D_3 \; \overline{R} = 0$.

Table 2 gives the specimen data and the calculated values of UCL and LCL on $\overline{X}$ and R charts. The calculated values of $\bar{\bar{X}}$ and $\overline{R}$ with their respective UCL and LCL lines are drawn on $\overline{X}$ and R charts. Points are said to be out of control if they lie above UCL or below LCL on any of the charts. In the preliminary chart, if out of control points are located on any of the charts, the corresponding observations are deleted, the control limits are recalculated. The control charts are thus got ready. It is to be followed up with collection of further samples of 5 cans from the weighing line at appropriate time intervals.

The values of $\overline{X}$ and R obtained from the samples are to be plotted on the chart. The charts (fig.1) give the points with further data obtained in this study (Table 3)

Fig.1

/Table 3/

TABLE 3 FURTHER OBSERVATIONS ON FILL WEIGHTS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
	9	6	7	4	4	10	5	5	5	5	15	12	4	4	10
	8	5	6	5	4	8	7	3	5	2	11	6	-2	3	9
	5	4	10	4	4	5	10	3	1	7	9	6	5	1	11
	4	3	12	4	4	9	3	4	4	5	8	7	4	2	9
	2	4	8	3	6	7	5	3	3	6	9	8	6	0	7
$\overline{X}$	5.6	4.4	8.6	4.0	4.4	7.8	6.0	3.6	6.6	5.0	10.4	7.8	3.4	2.0	9.
R	7	3	6	2	2	4	7	2	4	5	7	6	8	4	4

Action is called for to reduce the fill-weight, if points are above UCL on $\bar{X}$ chart, and to increase the fill weight if they are below LCL: If points are above UCL on R chart, some cans are having erratic weightment which has to be looked into and set right. Ideally the points should lie on either side of the $\bar{\bar{X}}$ or R lines within the control limits belt. If six or more points lie continuously on only one side of $\bar{\bar{X}}$ or R, but within the control belt, a trend is exhibited the causes for which require to be studied. If taken advantage, such a trend some times leads to savings in materials.

Though what is explained here is with reference to fill weights of cans, the use of $\bar{X}$ - R charts extends well beyond this: They can be applied for physical, chemical and organoleptic characteristics as well.

Control charts exist for defectives in items, implementation of which keeps a check on the percentage of defectives turned out at any stage. Suppose over a period, calculation of proportion of defectives, yielded the value 'P'. Then as in the case of average - range charts, calculation of preliminary control limits is necessary. They are given by

$$\text{UCL} : P + 3\sqrt{\frac{P(1-P)}{n}}$$

$$\text{and} \quad \text{LCL} : P - 3\sqrt{\frac{P(1-P)}{n}}$$

where n is the size of the sample examined for the presence of defective items. Let us consider this with respect to raw material of prawns used for processing. Let us suppose that data collected over twenty five batches, from samples of 500 from each batch, have shown a total of 325 pieces as spoiled ones. Then the proportion of defectives and the corresponding control limits are as follows:

Total Number of prawns examined : 500 x 25 = 12,500/-
Number of defectives : 325
Proportion of defectives : $\frac{325}{12500} = 0.026$

UCL : $0.026 + 3\sqrt{\frac{0.026(1-026)}{500}}$

$0.026 + 0.021 = \underline{0.047}$

LCL : $0.026 - 3\sqrt{\frac{0.026\ (1-026)}{500}}$

: $0.026 - 0.021 = \underline{0.005}$

Following the lines of approach of $\bar{X}$ - R chart, samples of 500 from subsequent batches should show defectives between 0.047 and 0.005 ie between 4.7 and 0.5 percentages of the samples. Procedures for taking action here also are when the points lie above U C L or below L C L. If points lie above U C L, turn out of defectives is higher than normal and requires corrective action. If they are below LCL, there is improvement in performance and the improvement can be maintained by a proper study of the situation.

4. Correlation and Regression

Correlation and regression are two related concepts, the former arising out of mutual dependence of two factors, both measured on the same item. Thus the length and weight of fish are correlated. Regression gives a functional relationship between the factors. The concept of correlation can be used with respect to quality characteristics which will help us to improve the quality of finished product by concentrating the attention on the connected factor at an earlier stage. If quality of raw material and finished product are correlated, it helps us in laying standards for raw material for the final product to meet the required specifications.

We illustrate the calculation of correlation coefficient, a measure of the correlation, with respect to the following ten pairs of values on two factors X and Y each pair measured on one item.

TABLE 4

X	Y	X	Y
9	7	4	3
8	9	3	6
7	7	3	1
7	8	1	2
6	7	2	2

With the usual notation, we have the following values:

$n : 10$ $\qquad S(X^2) : 318$

$S(X) : 50$ $\qquad S(Y^2) : 346$

$S(Y) : 52$ $\qquad S(XY) : 321$

Denoting by the following notation.

$$S(x^2) : S(X^2) - \frac{(S(X))^2}{n}$$

$$S(y^2) : S(Y^2) - \frac{(S(Y))^2}{n}$$

$$\text{and } S(xy) : S(XY) - \frac{(S(X)\,S(Y))}{n}$$

We have the following values:

$$S(x^2) : 318 - \frac{50^2}{10} = 318 - 250 = 68$$

$$S(y^2) : 346 - \frac{52^2}{10} = 346 - 270.4 = 75.6$$

$$S(xy) : 321 - \frac{50 \times 52}{10} = 321 - 260 = 61$$

Correlation coefficient, 'r' is given by

$$r = \frac{S(xy)}{\sqrt{S(x^2)\ S(y^2)}} = \frac{61}{\sqrt{V\ 68 \times 75.60}} = 0.851$$

Next it is to be seen whether the calculated correlation co-efficient is significant or not. In statistical terminology, by significance we mean whether the calculated value has arisen due to real significance in the original one, known as population, or has arisen due to sampling only. We attach importance to it if we can reasonably conclude that the value has arisen due to the nature of the population. For this purpose we refer to tabulated values in any standard text book on statistical methods and if our calculated value exceeds the tabulated values we can believe that our calculated value is significant. To refer to the tabulated value, we have to know what is known as degrees of freedom pertaining to our value. In the case of correlation coefficient, it is '2' less than the number of pairs considered for the calculation. Since we have considered 10 pairs, the degrees of freedom in our case work out to '8'. The tables give two values, the 5% value as 0.632 and 1% value 0.765. If our calculated value lies below 5% value, we feel that the value has no significance. If it exceeds 1% value, it is significant and if it lies between 5% and 1% values, while significant is indicated we require more data to establish the same conclusively. In our present case since the calculated value 0.851 exceeds the 1% value of 0.765, we conclude that X and Y are correlacted.

Positive value of correlation coefficient indicates that with increase in X, Y also increases, while negative value suggests that with increase in X, Y decreases. The value of correlation coefficient lies between -1 and +1.

Whenever correlation is established between two variables X and Y, we calculate the regression line between them to find the quantitative relationship. The equation of the line is given by

$$Y = a + bx$$

Where $b = \frac{S(xy)}{S(x)^2}$ and $a = \bar{Y} -$ [illegible]

With reference to our example here we get

$$b = \frac{61}{68} = \underline{0.8971}$$

$$\text{and } a = \frac{52}{10} - 0.8971 \times \frac{50}{10} = 5.2 - 4.4855$$

$$\underline{0.7145}$$

Hence equation of the regression line is given by

$$Y = 0.7145 + 0.8971\, x$$

Fig 2 gives the regression line with the observed values.

/ Fig 2 /

Where we find that the straight line is not adequate to describe the relationship between X and y we fit curvilinear regression between X and Y, in the form of curve.

5. Tests of significance

At differdnt stages of production, we face situations where we have to arrive at conclusions pertaining to batches of production based on study of samples. These are all grouped under tests of significance. We deal here with two of them viz., X^2 (Chi - square) test and 't' test with some specimen data.

i. Chi - Square test

This is a test of association between two factors. The steps involve classification of data with respect to two factors, carrying out calculations to arrive at chi-square (symbolically X^2) value and referring to the tabulated values with appropriate degrees of freedom to find whether our calculated value is significant or not. Let us consider the following example.

The data pertain to inspection result of 2,600 frozen blocks of shrimp with reference to the quality characteristic of texture and the final acceptability of the block. The score deductions on account of texture were 2,4 and 11 for different categories. The test results of 2600 ffozen blocks regarding their acceptability have shown that 2200 blocks were acceptable, and the rest non-acceptable.

It was proposed to study the effect of the score deduction for texture on the final acceptability of the frozen block. The final form of the data is as follows.

Table - 5.

Score deduction for texture	Acceptable number of frozen blocks	Non-acceptable number of frozen blocks	Total
11	80	220	300
less than 11	2120	180	2300
Total	2200	400	2600

The above data show that out of total 2600 of frozen blocks examined, 2200 were of acceptable quality and 400 of non-acceptable quality. 80 out of 2200 acceptable quality blocks, and 220 out of the 400 non-acceptable quality blocks received the score deduction of 11 for texture and the rest all less than 11. The study envisages the establishment of association between the score deduction and the final quality of the frozen blocks. The above figures are observed values and are symbolically represented by 'O'. There are two rows and two columns giving rise to four cells. On the assumption that there is no association between the score deduction for texture on the corresponding acceptable nature of the block ie treating both these factors as mutually independent, we calculate the expected values, symbolically represented by 'E' for each cell.

The expected value for each cell is obtained by the multiplication of the corresponding row total with that of the column total and dividing by the gfand total. For instance, the expected value for 'score deduction of 11 'and' acceptable blocks is $\frac{300 \times 2200}{2600} = 253.85$

Similarly we calculate for the other cells. The calculations yield the following table of expected values.

/ Table - 6 /

Expected values

Score deduction for texture	Acceptable number of frozen blocks	Non-acceptable number of frozen blocks	Total
11	253.85	46.15	300
Less than 11	1946.15	353.85	2300
Total	2200.00	400.00	2600

The column and row total of expected values should be the same as the corresponding ones of observed values.

With 'O' and 'E' already explained, $\frac{(O - E)^2}{E}$ is to be calculated for each of the cells. For instance for the first row and the first column $\frac{(O - E)^2}{E} = \frac{(80-253.85)^2}{253.85}$

$$= \underline{119.06}$$

The sum of $\frac{(O - E)^2}{E}$ for all the cells gives the value of chi-square. Here calculated value of chi-squate is $119.06 + 15.53 + 654.90 + 85.41 = 874.90$. If 'm' denotes the number of rows and 'n' the number of columns, the associated number of degrees of freedom is $(m-1)\ (n-1)$. Since each of them is 2 in this example, the number of degrees of freedom is $(2-1)(2-1)$ ie $1 \times 1 = 1$ Entering the tabulated value of X^2 (from any standard book on statistics), with 1 degree of freedom, we find the values as follows.

5% value : 3.85
1% value : 6.64

Our calculated chi-square value is far in excess of 1% table value suggesting very strong association between the two criteria ie score deduction for texture and acceptablity of the block are strongly associated.

ii. 't' test This is a very important test which a statistician is frequently called upon to perform. This is with the specific requirement of comparison of two means. Comparison of physical, chemical or organoleptic characteristics for two batches of material or two different processes or two lots of products etc requires the application of this test. Let us consider the following example.

It was proposed to study the effect of blanching of prawns for two different durations on the corresponding moisture content. This study is important in that it is related to the quality of the final product.

Five samples from each of them termed as A and B for convenience, have given the following moisture contents.

Table - 7

A	B
72.1	72.8
71.3	73.7
70.8	74.3
71.6	73.4
72.5	71.9

The test has to be applied for the above data to understand whether there is any difference between the moisture contents under both the conditions.

The calculations are as follows:

If n_1 and n_2 represent the size of samples from A and B, X, and X_2 the values from A and B, we have.

$n_1 = n_2 = 5$

$S(X_1) = 358.3$ $S(X^2) = 25677.35$

$S(X_2) = 366.1$ $S(X_2^2) = 26,809.19$

$$\bar{X}_1 = 6\ 71.66 \qquad \bar{X}_2 = 73.22$$

$$\bar{X}_2 - \bar{X}_1 = 73.22 - 71.66 = 1.56$$

$$S(x_1^2) = S(X_1^2) - \frac{(S(X_1))^2}{} = 25{,}677.35 - \frac{358.3^2}{5}$$

$$= \underline{1.5720}$$

$$S(x_2^2) = S(X_2^2) - \frac{(S(X_2))^2}{n_2} = 26{,}809.19 - \frac{366.1^2}{5}$$

$$= \underline{3.3480}$$

$$\text{Pooled } S^2 = \frac{S(x_1^2) + S(x_2^2)}{n_1 + n_2 - 2} = \frac{1.5720 + 3.3480}{5 + 5 - 2} = \frac{4.9200}{8} = \underline{0.6150}$$

$$\text{Pooled } S = \sqrt{0.6150} = 0.7842$$

$$t = \frac{\bar{X}_2 - \bar{X}_1}{S} \sqrt{\frac{n_1\ n_2}{n_1 + n_2}} = \frac{1.56 \text{ X } 1.5811}{0.7842} = 3.15$$

The number of degrees of freedom is $(n_1 + n_2 - 2)$ ie 8 in this case. Referring to 't' tables from any book on statistics, we find the following values of 't' for 8 degrees of freedom.

5% value : 2.31
1% value : 3.36

Our calculated 't' value exceeds 5% value, but lies below 1% value. Thus while the moisture contents between the two different processes differ significantly, it could not be conclusively established because of insufficient data. If a few more samples are obtained from each of the batches, it could have been convincingly established that moisture content under B is higher than that of A.

What we have seen here is comparison of two batches of material. When we want to carry out comparison for more than two, we perform what is known as Analysis of variance. The text books mentioned at the end are suggested for further details on this topic.

6. Conclusion

We have covered some of the important applications of statistical techniques. What is covered is only an approach for the application of the techniques. We tried to understand how the application of these techniques could be helpful in solving some of the frequently arising problems in the industry. There are quite a good number of more applications, for instance in tasto testing, production planning and control etc. Some of the text books mentioned below give the methods concerning the above. A proper appreciation of the problem and the application of techniques can achieve much in the industry.

Books for further study

1)	Brownlee K.A.	'Industrial Experimentation' - Chemical publishing Co., New York.
2)	Duncan. A.J.	'Quality control and Industrial statistics' - Richard D. Irwin. Inc. Homewood, III.
3)	Grant.E.L.	'Statistical Quality control' - M.C. graw Hill Book Co.,New York.
4)	Kramer, A., and Twigg. B.A.	'Fundamentals of Quality Control for the Food Industry' - The AVI Publishing company Inc. West Port, Conneticu.

tmR/

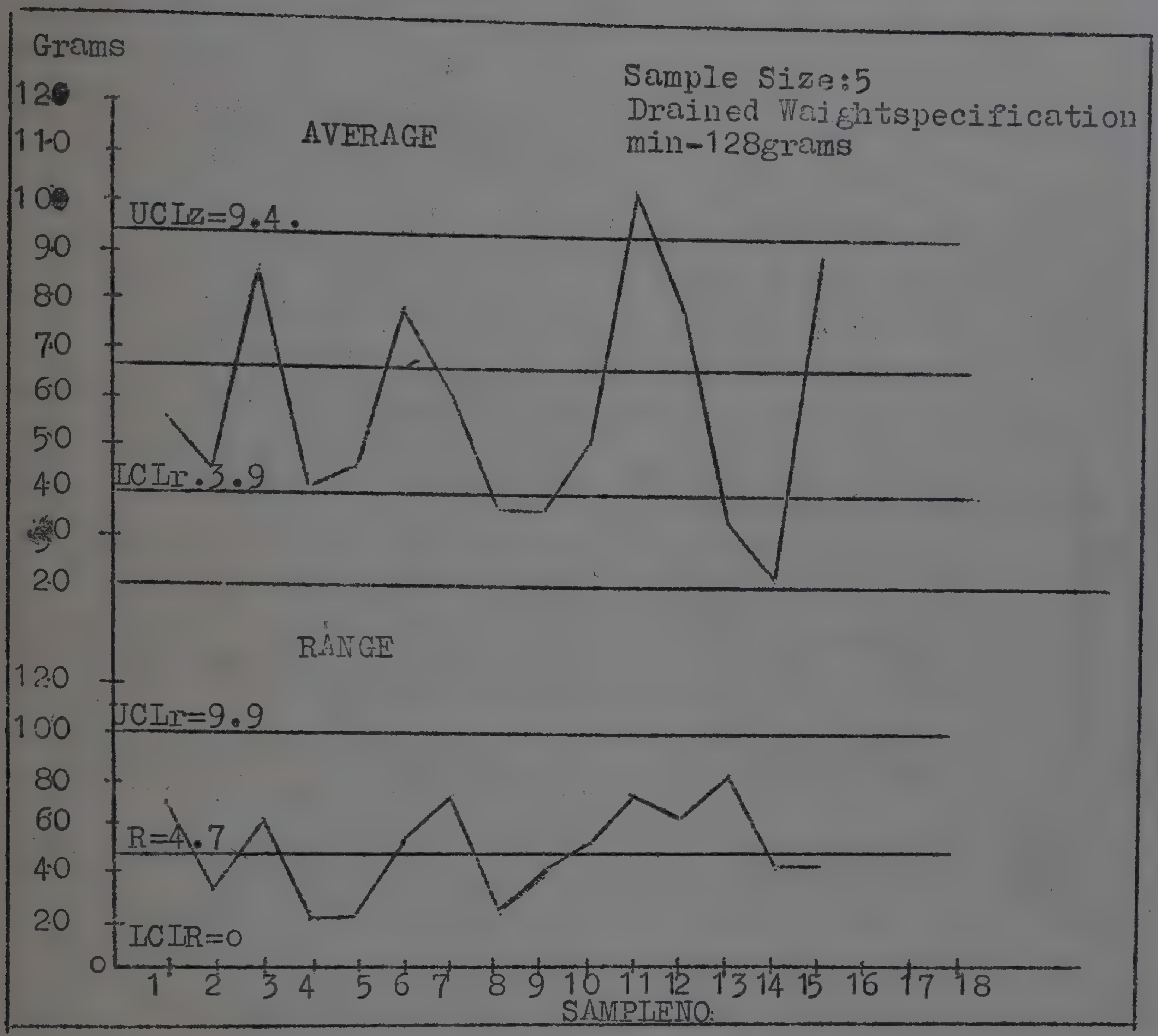

FIG.I.CONTROL CHART FOR FILL WEIGHTS OF SHRIMP CANS

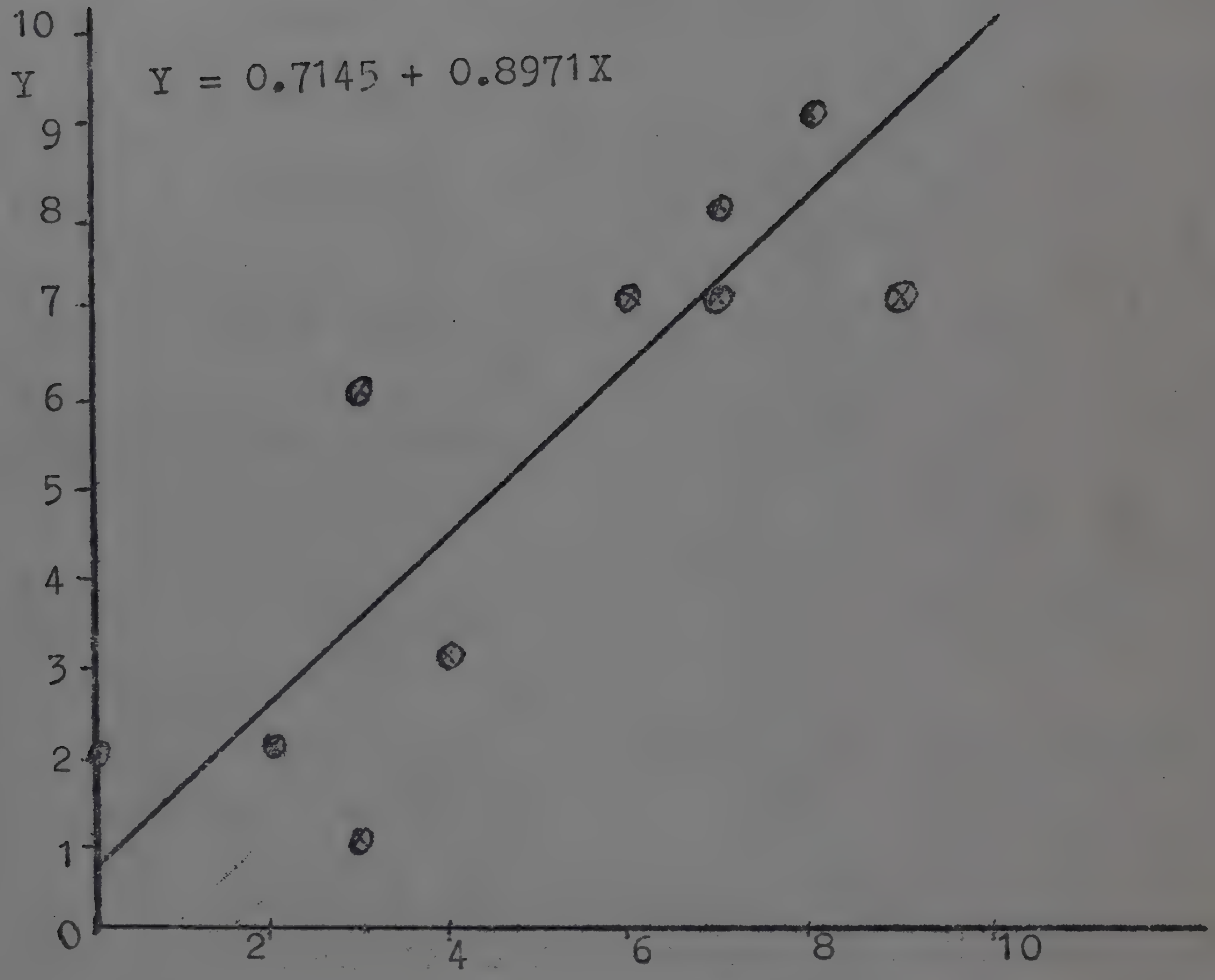

FIG.2. REGRESSION OF Y ON X

MANAGEMENT TECHNIQUES

By

P. V. Mathew

What is Management?

Management is a word used by different people with varying meanings. The term "Management" is used here to refer to an activity or process or to a group of people who manage within a particular organization.

One frequently quoted definition is "Management is getting things done through other people". The manager must not only understand how to get people to do what he wants them to do, he must also know what they should be doing - what results should be achieved, what each person and group should contribute to the common effort and how the results can best be achieved withou duplication of work. Another rather comprehensive definition is "Managing is the task of the manager to establish and maintain an internal environment in an enterprise where individuals working together in groups, can perform efficiently and effectively towards the attainment of group goals". In other words, it is the manager who is charged with the responsibility of undertaking those actions calculated to make it possible for individuals to make their best contributions toward group objectives.

Functions of Management

In order to understand the functions of management we must know how the manager does his task. When a man becomes a manager, he may or may not continue to do part of the actual work, but he also takes on new duties that are entirely managerial in character. He must plan work for others, select his subordinates and train them, decide what each of them should do, motivate those under him to do their best and check on their progress. A logical method of classifying managerial functions is to group them around the activities of Planning, Organising, Staffing, Directing and Controlling. In practice it is not always possible to slice all managerial activities neatly into these categories, since the functions tend to coalesce.

In classifying the functions of managers, one must distinguish clearly those of functional operation, such as selling, manufacturing, accounting and purchasing. These differ from one enterprise to another but the basic tastes of the manager, as a manager are common to all.

Planning

Planning involves selecting objectives and the strategies, policies programmes and procedures for achieving them, either for the entire enterpris or for any organized part thereof. Planning is ofcourse, decision-making, since it involves selecting among alternatives.

Steps in Planning

1. Being aware of opportinity
2. Establishing objectives
3. Premising and forecasting
4. Determining alternative courses of action
5. Evaluating alternative courses
6. Selecting a course of action
7. Formulating derivative plans.

Objectives

Objectives or goals are the ends toward which activity is aimed. While enterprise objectives constitute the basic plan of the firm, a department may also have objectives. Its goals naturally contribute to the attainment of enterprise objectives, but the two sets of goals may be entirely different. Thus, if the objective of a business is to make a profit in electronics, the goal of a manufacturing department might be to produce the required number of calculators of a given design and quality at a given cost. These objectives are consistent, but they differ in that the manufacturing department alone cannot assure a profit.

Managing by objectives (MBO)

Management by objectives is a simple but powerful system of managing. Without clear objectives, managing is haphazard and random, and no individual, no group can expect to perform effectively or efficiently unless a clear goal is sought. MBO is a system wherein the its common goals, define each individual's major areas of responsibility in terms of the results expected of him and use these measures as guide for operating the unit and assessing the contribution of each of its members.

Characteristics of an MBO System

- Some form of corporate or unit plan by which the objectives are laid down
- Measurable and time - bounded objectives for each managerial position.
- The objectives for each position are established by the job holder and the boss together
- Mutually agreed job improvement plans to facilitate the accomplishment of objectives
- Periodic reviews and updating, wherever necessary, of the mutually agreed objectives by the boss and the subordinate together
- Such mutually agreed objectives form the basis of performance evaluation
- Sharper definition of responsibilities and authorities for positions which brings in better clarity in the organisation.
- Aligning and linking of objectives up, down and across.

Premising and forecasting.

Planning premises are the anticipated environment in which plans are expected to operate. They include assumptions or forecasts of the future and known conditions that will affect the course of plans, such as prevailing policies and existing company plans that control the basic nature of supporting plans.

Sales forecasting

One of the major planning premises in the typical business enterprise is the sales forecast. To a considerable extent it underlies various new product, production, and marketing plans, and it also reflects conditions of the market place which are external to the firm.

...4/-..

Methods:

(1) Sales force composite method

This method is to ask salesmen to forecast sales for their distri and have these estimates reviewed by the regional sales manager and then by the head-office sales manager. Sometimes salesmen are given guides in the form of company planning premises as to business conditions generally. This method is based on the belief that those closest to the sales picture have the best knowledge of the market.

Users expectation method:

Many companies, particularly those serving industrial customers or where a few large customers are dominant, find it useful to base their forecasts on expected purchases by these customers.

Statistical methods:

The most relied upon approach to sales forecasting is the application of various statistical methods.

a) Projection of trend by moving average or other methods

b) Regression analysis

If close correlation can be established between company sales and some broad national index that can be used with a reasonable degree of accuracy, such as gross national product, national income or consumers disposable income. Such correlation, either directly or with a lag or lead of a given time period can give a company a useful and highly reliable basis for sales forecasting.

Planning and decision making

Decision making - the selection from among alternatives of a course of action is at the core of planning. It involves determination of alternative courses, evaluation of alternatives and selection of a course of action

In selecting from among alternatives, three bases for decision are open to the manager - experience, experimentation and research and analysis.

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The experienced manager usually believes, often without realizing it, that the things he has accomplished and the mistakes he has made furnish an almost infallible guide to the future. There is danger in relying on one's past experience as a guide for future action. In the first place, it is quite unusual that people recognise the underlying reasons for their mistakes or failures. In the second place the lessons of experience may be entirely unsuitable to new problems.

The experimental technique should be utilized as a last resort after other planning techniques have been tried. It is clearly the most expensive of all techniques, especially where heavy expenditure in capital and personnel are necessary to try a programme.

The most generally used and certainly a most effective technique for selecting alternatives, when major decisions are involved, is research and analysis. It involves a search for relationships between the more critical variables, constraints and premises that bear upon the goal sought. One of the most comprehensive research and analysis approaches to decision making is Operations Research.

Operations Research and Planning

OR is the application of Scientific method to the study of alternatives in a problem situation, with a view to providing a quantitative basis for arriving at an optimum solution in terms of the goals sought. Thus the emphasis is on scientific method, on the use of quantitative data, on goals, and on the determination of the optimum means of reaching the goal.

Some tools of OR

1. Waiting Line or Queuing theory

This theory uses mathematical techniques to balance the costs of waiting lines versus the costs of preventing waiting lines by increased service. It is based on the premise that although delays are costly, the cost of eliminating them may be even more costly.

Four basic structures of waiting line situations occur. The simplest situation is where arriving units form a single line to be serviced by a single processing facility, for example, a oneman barber shop. This

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is called the single channel, single phase case. If the number of processing stations is increased (two or more barbers) but still draws on the one waitin line, we have a multiple channel, single phase case, since a customer can be serviced by abyone of the barbers. A simple assembly line has a number of service facilities in series and is the single channel multiple phase case. Finally we have the multiple-channel, multiple-phase case which might be illustrated by two or more parallel production lines.

examples of waiting line situations

ships entering a port

machines or facilities waiting for maintenance crew

Doctor's office

automobiles waiting at a petrol station

2. Linear Programming

Linear programming, one of the most successful applications of operations research, is a technique for determining the optimum combination of limited resources to obtain a desired goal. It is based upon the assumption that a linear or straight line relationship exists between variables and that the limits of variations can be determined.

Areas of application:

1) transportation or distribution problems
2) allocation of production facilities when alternate routings are available
3) allocation of limited funds to various items of inventory to minimise losses from less than optimal inventory levels.
4) Product mix problems
5) Make or buy decision
6) Scheduling of production to meet sales forecast, using inventory fluctuations and overtime work

Project Planning methods

1) PERT/CPM
2) Line of balance

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II. Organising

The process of organising involves:

1. Establishment of enterprise objectives
2. Formulation of derivative objectives, policies and plans
3. Identification and classification of activities necessary to accomplish these
4. Grouping these activities in the light of human and material resources available and the best way of using them
5. Delegating to the head of each group the authority necessary to perform the activities
6. Tying these groupings together horizontally and vertically through authority relationships and information systems.

Basic concepts in organising

1. Authority:

Authority is the key to management job. It is the right inherent in a position to utilize discretion in such a way that enterprise or department objectives are set and achieved

2. Responsibility:

Responsibility may be defined as the obligation of a subordinate to perform assigned and implied duties. Responsibility has no meaning except as applied to a person. It arises from the superior - subordinate relationship, from the fact that someone has the authority to require specified services from another person.

3. Delegation:

Authority is delegated when organization discretion is vested in a subordinate by a superior. The process of delegation involves the determination of results expected, the assignment of tasks, the delegation of authority for accomplishing these tasks and the exaction of responsibility for their accomplishment.

Guides for effective delegation:

1. Define assignments and delegate authority in the light of results expected.
2. Select the man in the light of the job to be done
3. Maintain open lines of communication
4. Establish proper controls
5. Reward effective delegation and successful assumption of authority

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III. Staffing:

The function of staffing has to do with manning the organization structure to assure that an enterprise can be competently operated. In particular, staffing involves the proper and effective selection, appraisal and development of personnel to fill the roles designed into an organization structure.

IV. Directing:

Directing is the inter personal aspect of managing by which subordinates are led to understand and contribute effectively and efficiently to the attainment of enterprise objectives. To direct subordinates effectively, a manager is concerned with motivation, communication and leadership.

V. Controlling:

The managerial function of controlling is the measurement and correction of the performance of activities of subordinates in order to make sure that enterprise objectives and the plans devised to attain them are being accomplished. It is the function whereby every manager from Chairman to foreman makes sure that what is done is what is intended. Since control implies the existence of goals and plans, no manager can control without them. He cannot measure whether his subordinates are operating in the desired way unless he has a plan, however vague or for however brief a period.

Some control devices

1. Budget:

It is the formulation of plans for a given future period in numerical terms.

2. Break-even Analysis

It depicts the relationship of sales and expenses in such a way as to show at what volume revenues exactly cover expenses. At any lesser volume, the company would suffer a loss and at a greater volume it would enjoy a profit.

3. Return on investment analysis

This yardstick is the rate of return that a company or a division can earn on the capital invested in it.